Weather and Electronic Charts

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Sandy Wells

MIT Bluewater Sailors

Aim of this session

Over the next two hours I hope to give you an overview of two seemingly disparate areas, weather and electronic chart plotting. At the end I hope you understand why you really need to talk about the weather at sea and electronic chart plotting together.

Goals:

- Understand the forces that give rise to the weather
- Know the clouds associated with approaching fronts
- Where to find a range of weather forecast products
- Have a working understanding of OpenCPN, an open source ECDIS (Electronic Chart Display and Information System)
- Understand how to import and visualize weather and current grids
- Understand how to create optimal routes in OpenCPN

Of necessity we will not go into any topic in detail; there are plenty of sites on the web for further exploration.

Agenda

- **Weather Basics**
  - Where does the weather come from?
  - Fronts and air masses
  - Cloud types
  - Wind, waves, and warnings
  - What can you tell from looking at the skies and barometer?
  - Wave heights (wind and fetches)

- Forecasting products
  - The wide range and uses of forecasting products
  - Gribs (General Regularly-distributed Information in Binary form)

- Planning a Daysail
  - A few days out - Windy, PredictWind, etc.
  - A few hours out - your local weather radar, forecast and lightning
  - During the sail: lightning and eyes

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  - Intro to OpenCPN
  - Loading and updating charts
  - Requesting and importing Gribs
  - Using the routing plugin with weather and current forecasts

The Causes of Weather

- Density
- Coriolis Force
- Atmospheric pressure
- The global wind pattern
- Wind and weather
- Air masses
- Atmospheric pressure
- Isobars
- Dew point (determines bottom of cloud formations, fog, and rain)

The Causes of Weather

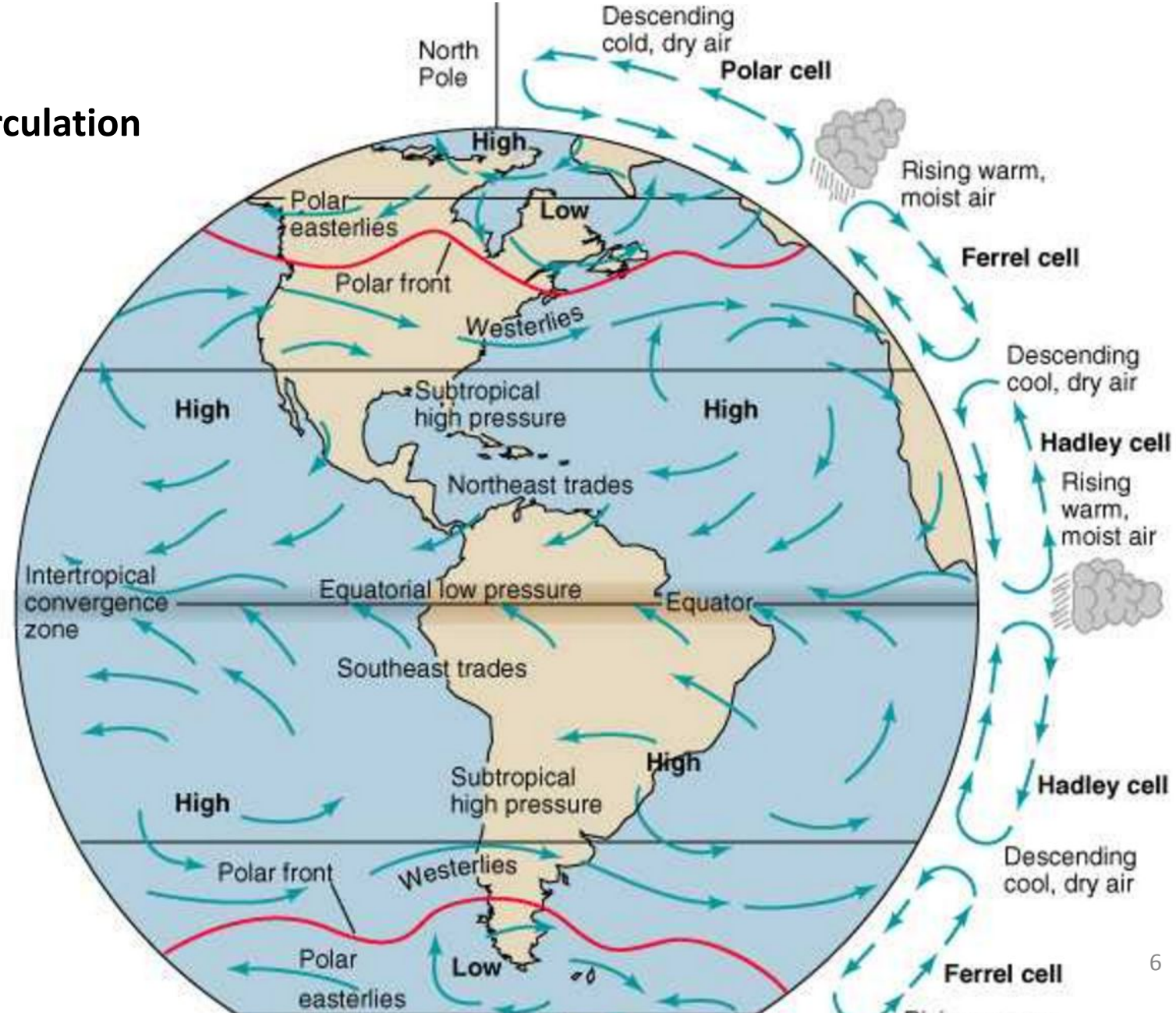
Weather is caused by the interactions of air masses that are not in equilibrium – different pressures, temperatures, and moisture content.

Air masses are vast expanses of air that have similar densities, temperatures and moisture and arise from different geographical regions; they move as part of the prevailing winds.

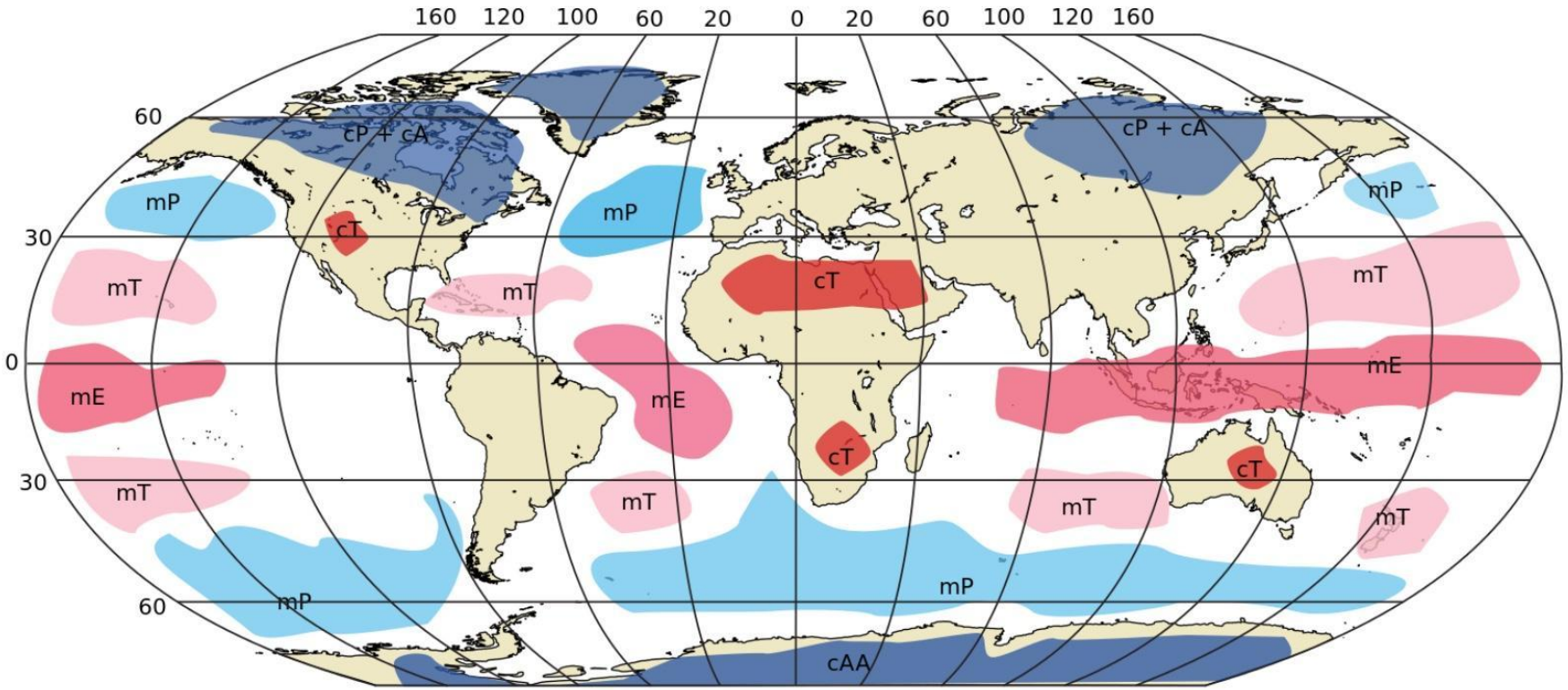
When two dissimilar air masses meet, their boundary is a ‘front’, which is what gives rise to much of the interesting weather.

The Causes of Weather

Global Circulation



The Causes of Weather

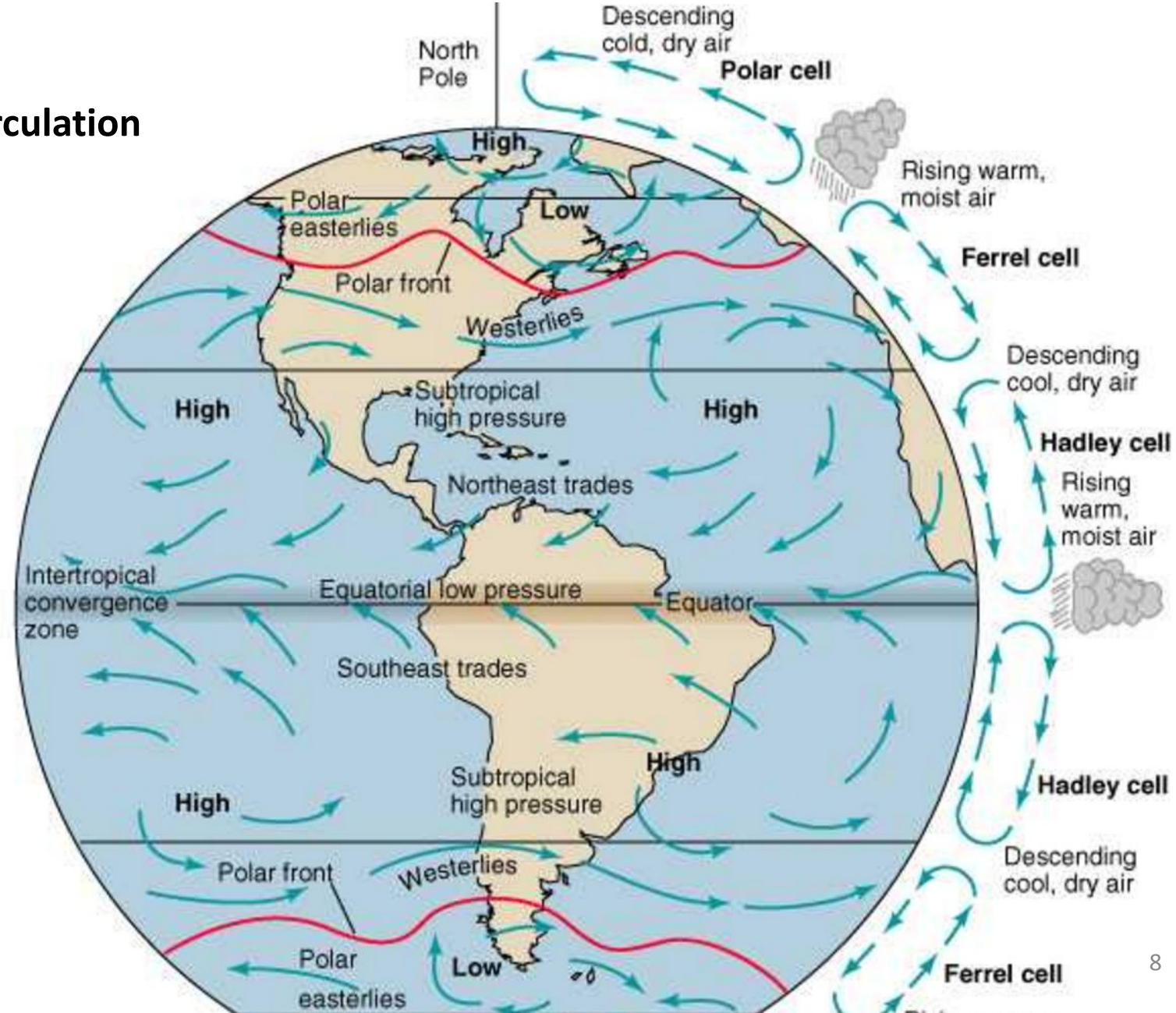


Air masses and their location of origin (Public Domain).

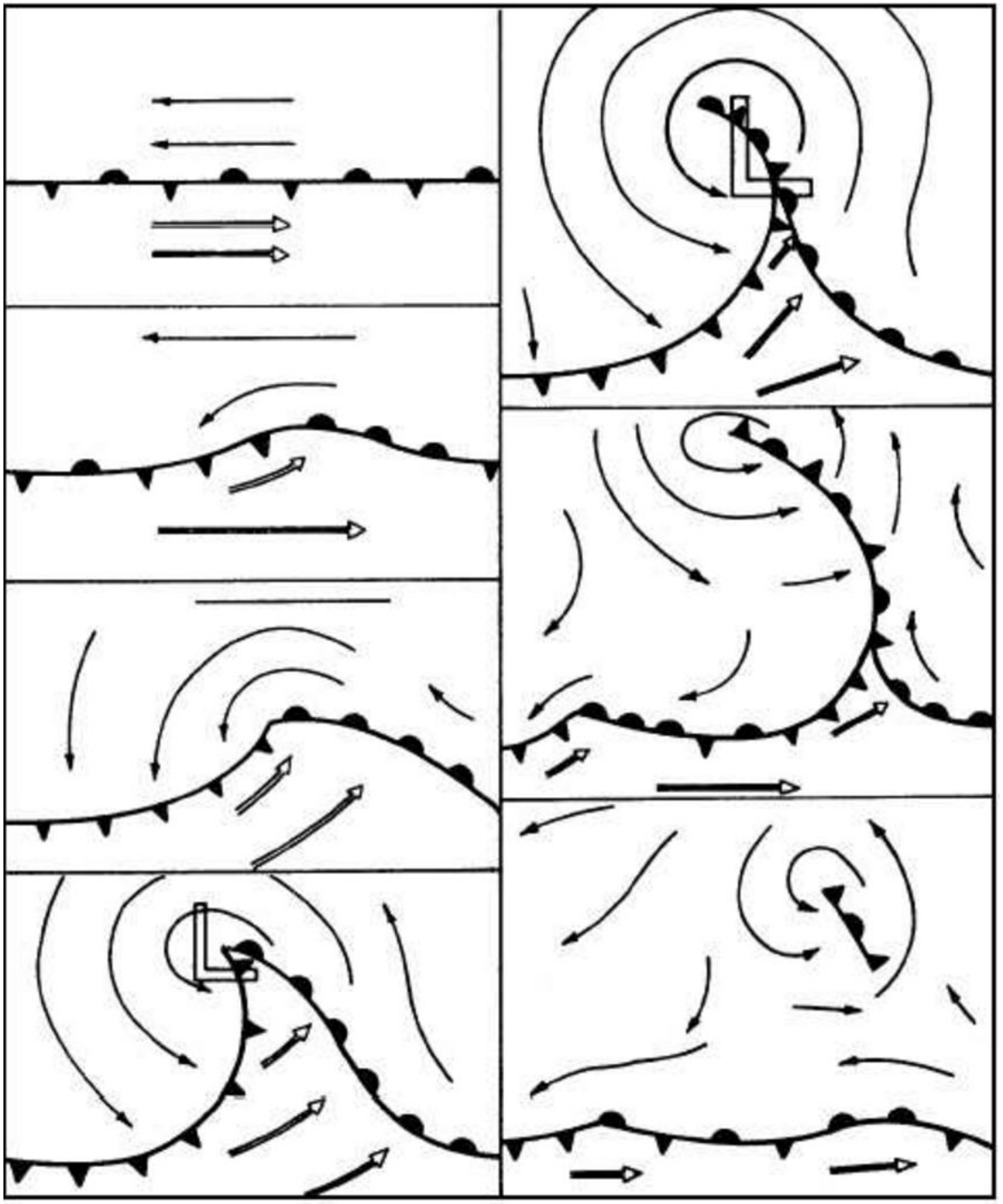
Maritime (m) air masses are moist, continental © air masses dry. Temperature is associated with their latitude (Equatorial, Tropical, Polar, Arctic/Antarctic)

The Causes of Weather

Global Circulation



Fronts and Weather Systems



Fronts and Weather Systems

Cloud Types

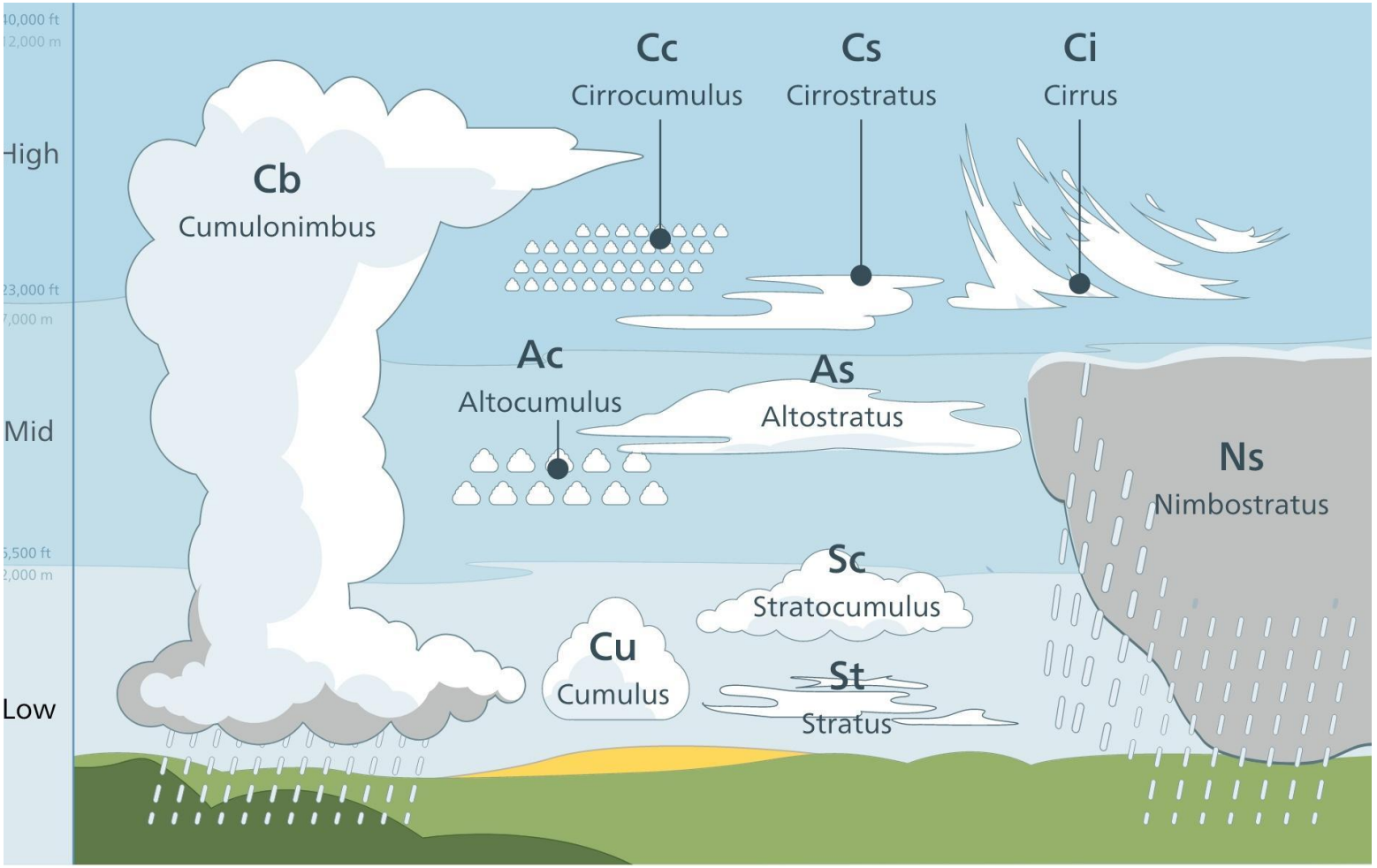
The basic categorization: shape and height

- Cumulus clouds are puffy and vertical
- Stratus clouds are flat layers
- Cirrus – detached or semi-detached filaments

‘ ith precipitati

Fronts and Weather Systems

Cloud Types

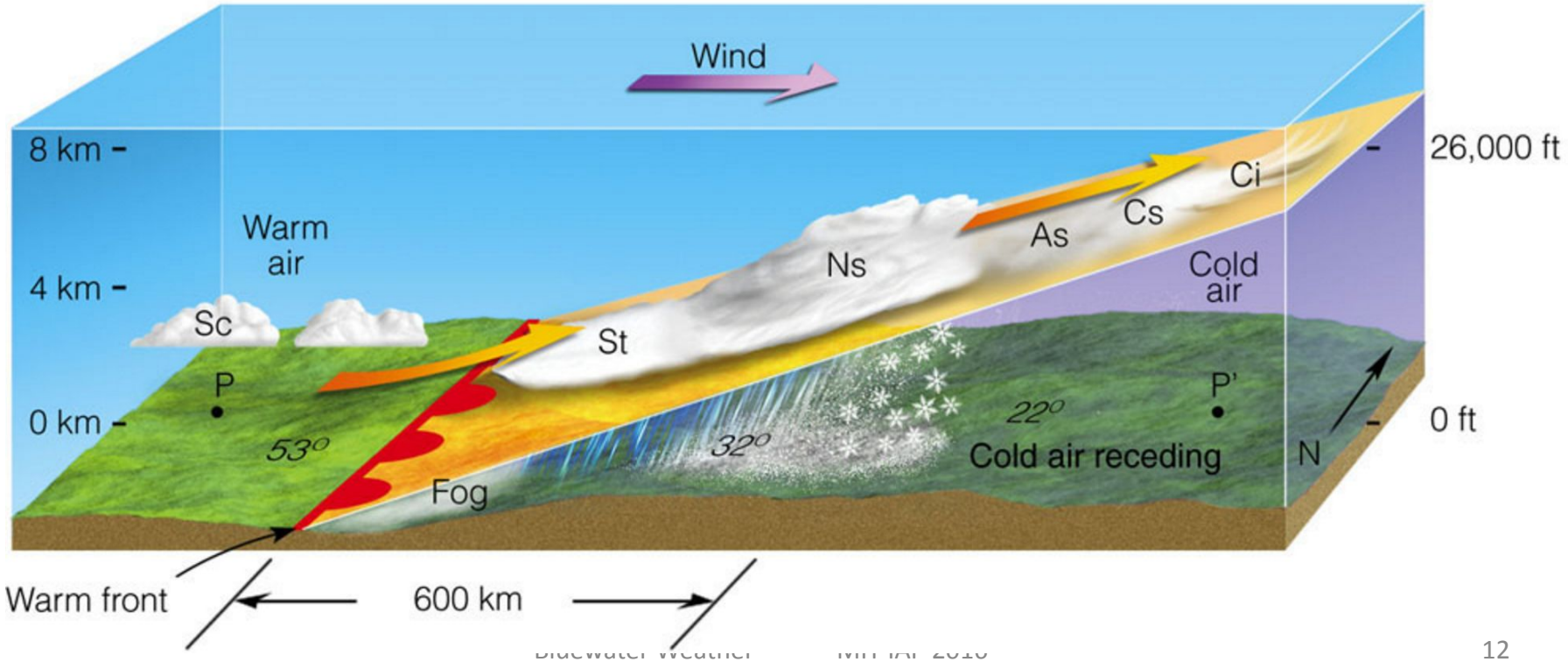


By Valentin de Bruyn
https://commons.wikimedia.org/w/index.php?curid=17899555

Fronts and Weather Systems

In **a Warm Front** warm air slides over cold air

- Moves slowly 10-15kts
- Weather deteriorates gradually
- Approaching clouds seen from 1000+ miles
- Symbol marking the front is a line with red half circles (warm air is behind the line)



Jet Stream Cirrus

Altostratus

Stratus

Low-hanging stratus wisps

Fronts and Weather Systems

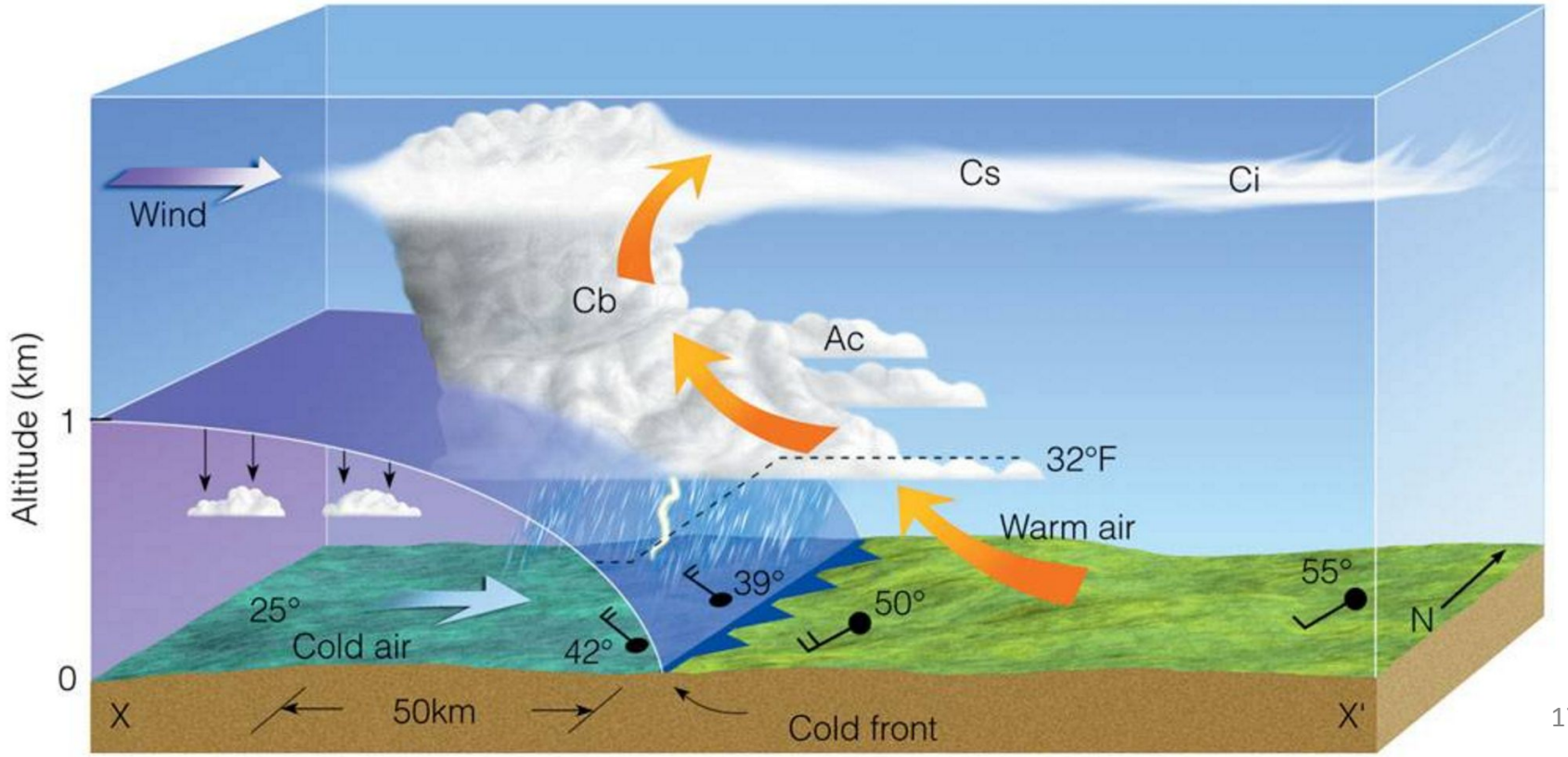
In **a Cold Front** the Cold Air pushes underneath warm air and causes the air to rise violently and rapidly

– Cold fronts move fast 20- 35 kts

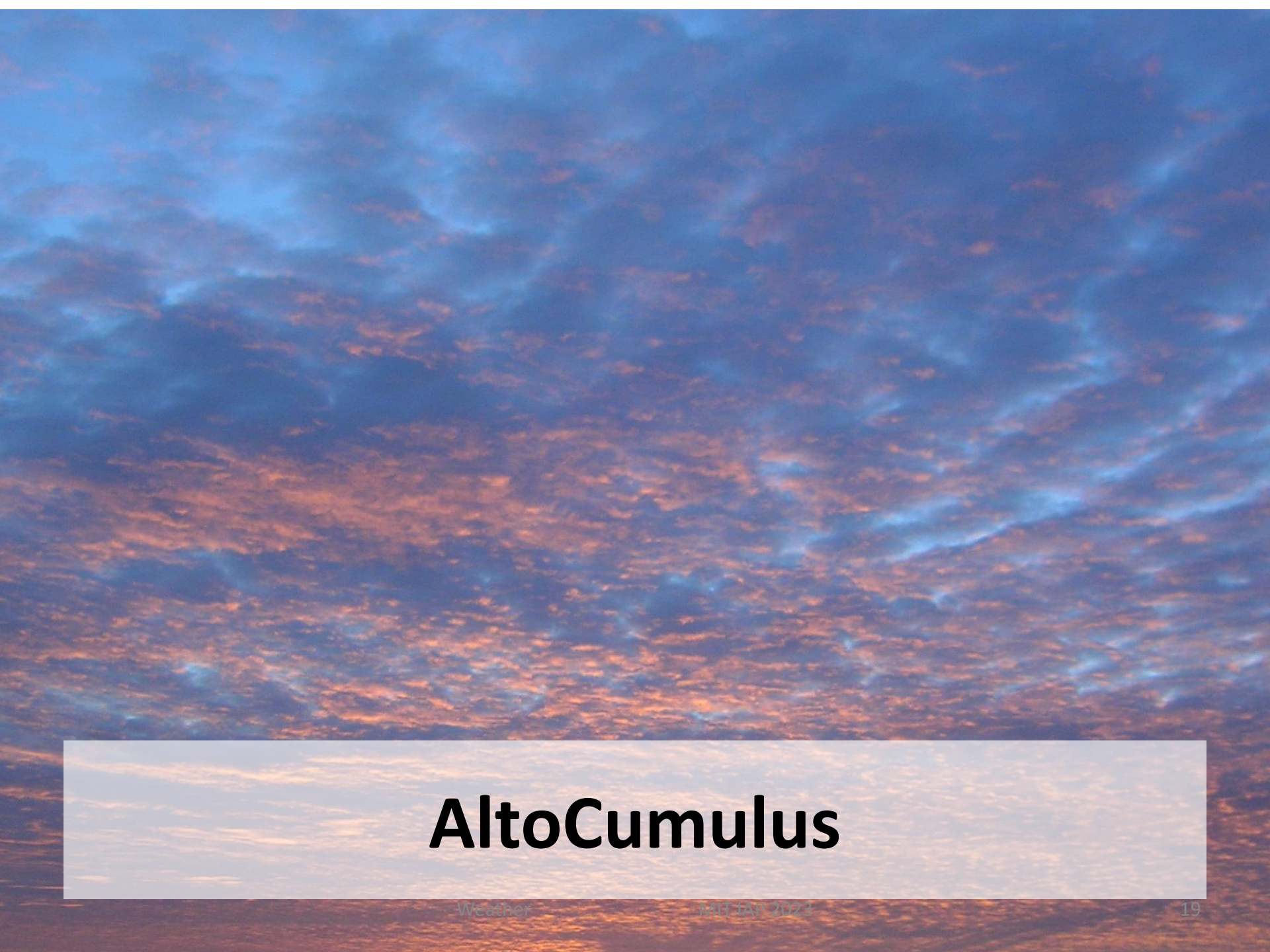
– Generally move E-SE

– Weather deteriorates rapidly

– Approaching clouds seen 50- 150 miles ahead of cold front



Jet Stream Cirrus



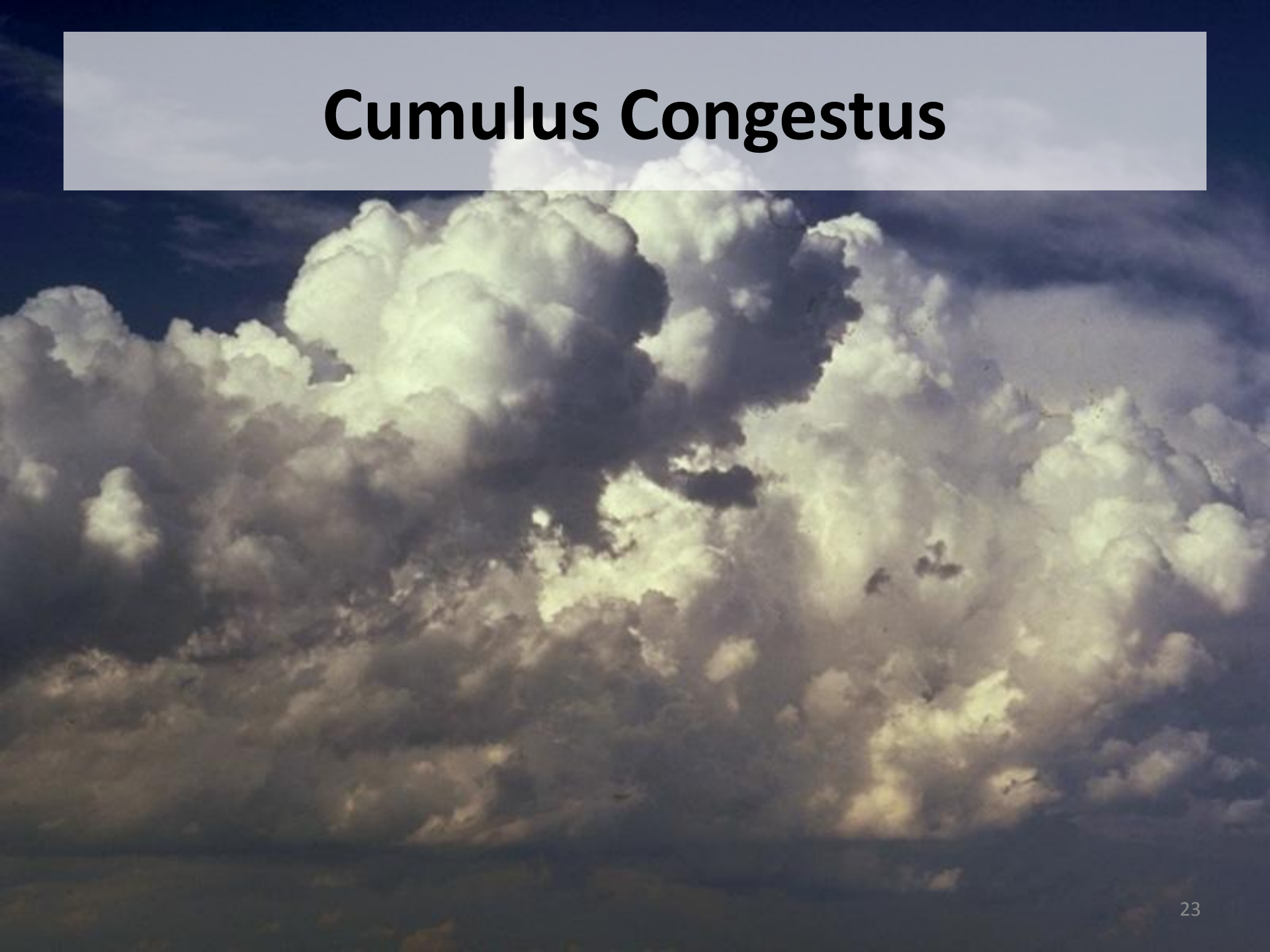
AltoCumulus

Cumulonimbus

Derecho

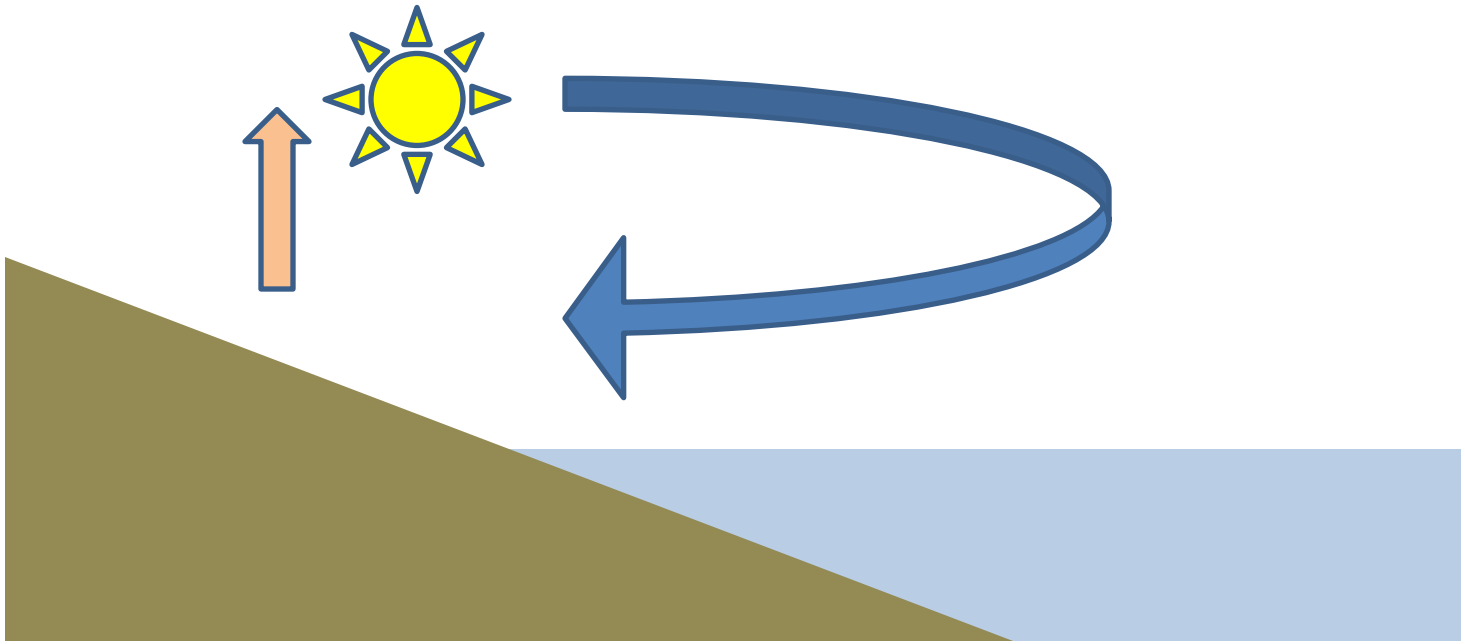
Cumulus of Fair Weather

Cumulus Congestus



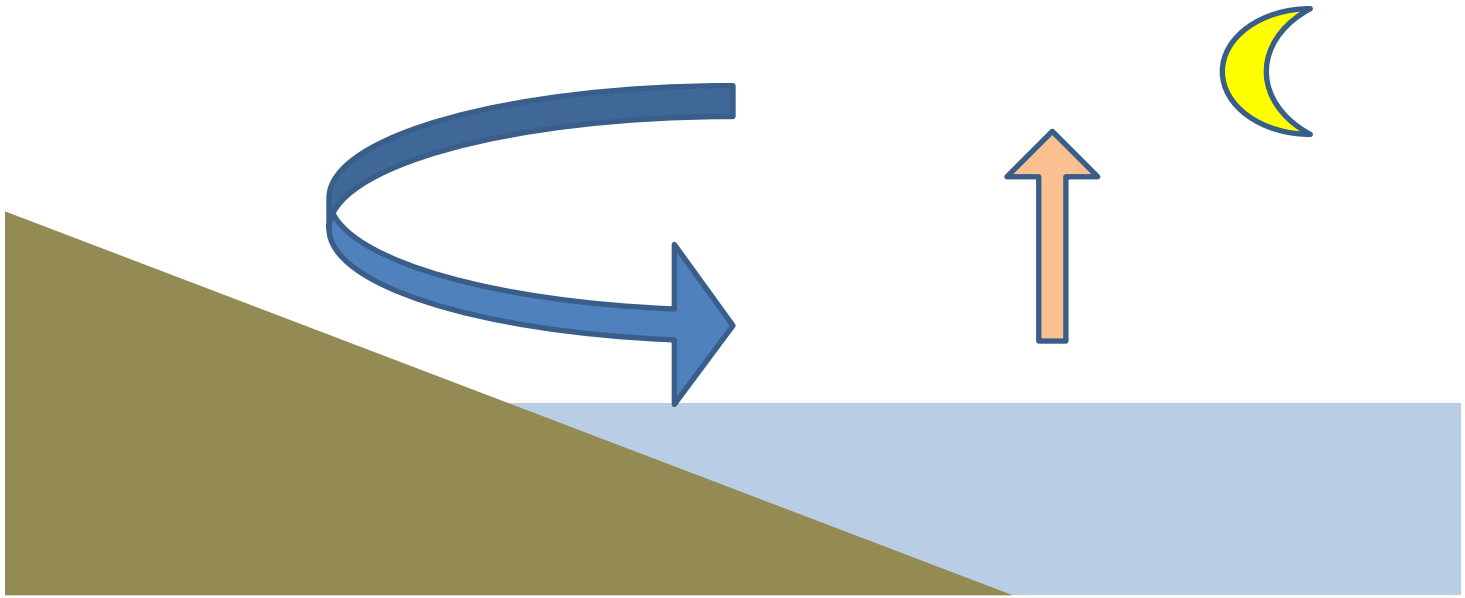
The Boundary Layer: Effects of Land Morning to Afternoon

- Land heats up, air rises, cools, sinks again, wind picks up
- Warm air rises over land, cool air from the sea moves inland (sea breeze)



The Boundary Layer: The Effects of Land Evening to Night

- Land cools, convection stops, winds die down
- Warm air rises from the water, cool air flows down coastal slopes (land breeze)



Questions?

Ben Nevis Inn
WEATHER FORECASTING STONE
CONDITION
FORECAST
Stone is Wet
Rain
Stone is Dry
Not Raining
Shadow on Ground
Sunny
White on Top
Snowing
Can't see Stone
Foggy
Swinging Stone
Windy
Stone Jumping Up & Down
Earthquake
Stone Gone
Tornado

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NOAA Web Site

https://www.weather.gov

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME FORECAST PAST WEATHER SAFETY INFORMATION EDUCATION NEWS SEARCH ABOUT

Local forecast by "City, St" or ZIP code

Enter location ... Go

Location Help

Snow for Eastern Great Lakes and Central Appalachians into Mid-Atlantic; Slow Improvement in Southern California

Snow showers, a few squalls, from the Great Lakes region into the central Appalachians and mid-Atlantic through today; Travel conditions may be affected. For southern California, slowly improving conditions as winds diminish later today. Friday and into the holiday weekend, an arctic surge will dive southward with snow showers and squalls for the front range of the Rockies as colder air moves east Read More >

ACTIVE ALERTS FORECAST MAPS RADAR RIVERS, LAKES, RAINFALL AIR QUALITY SATELLITE PAST WEATHER

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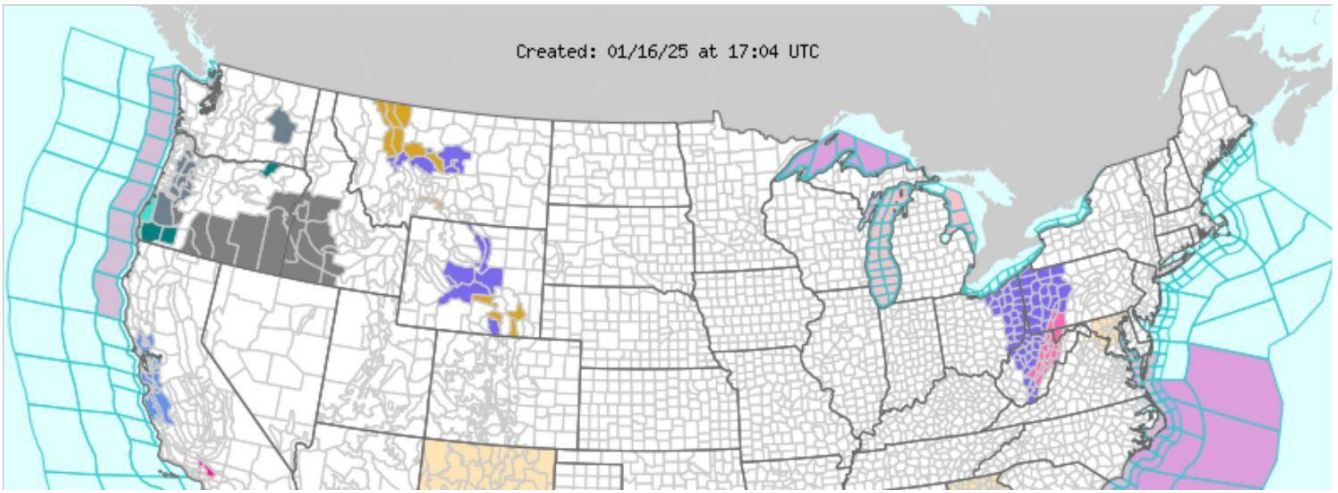
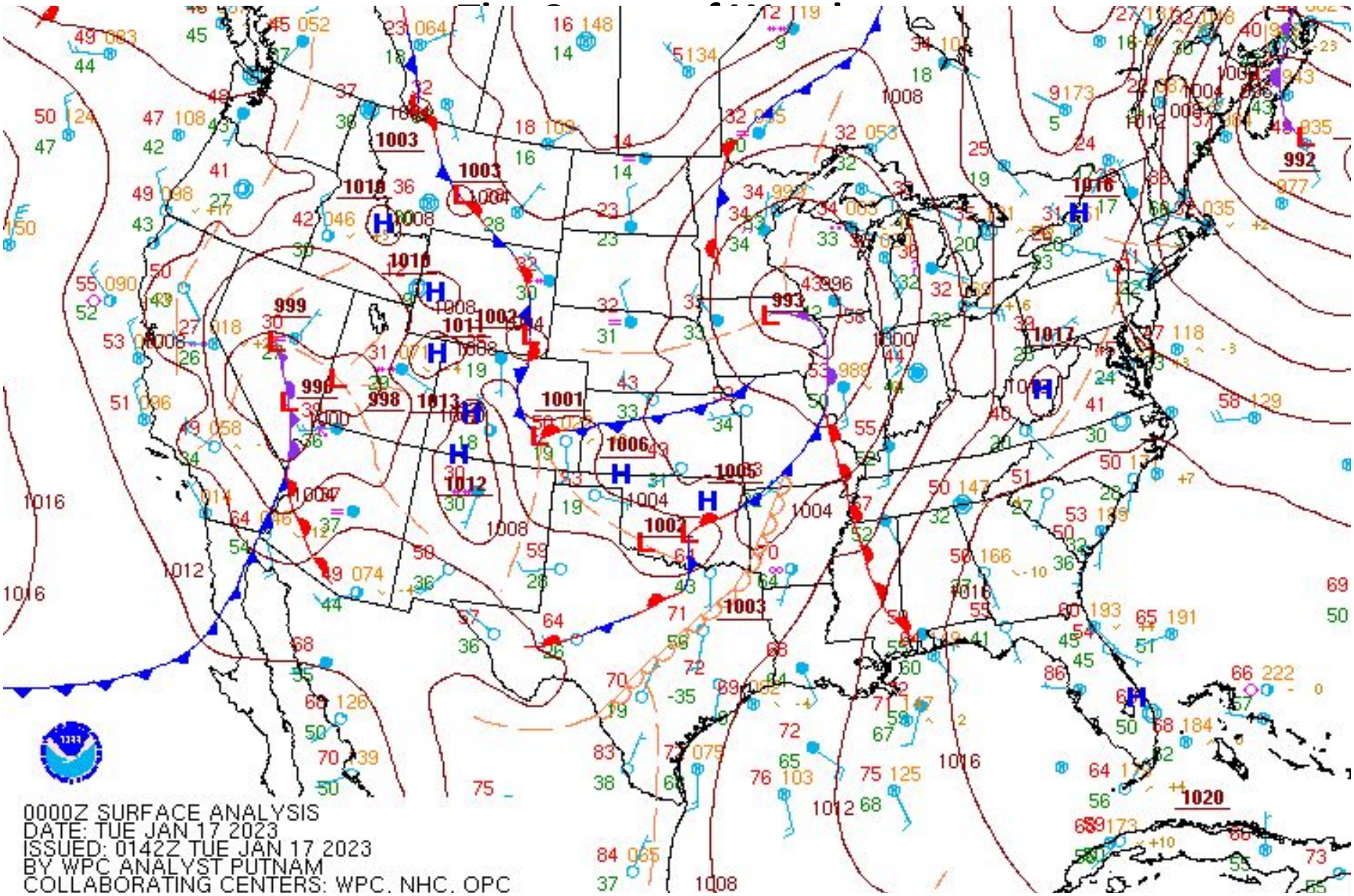
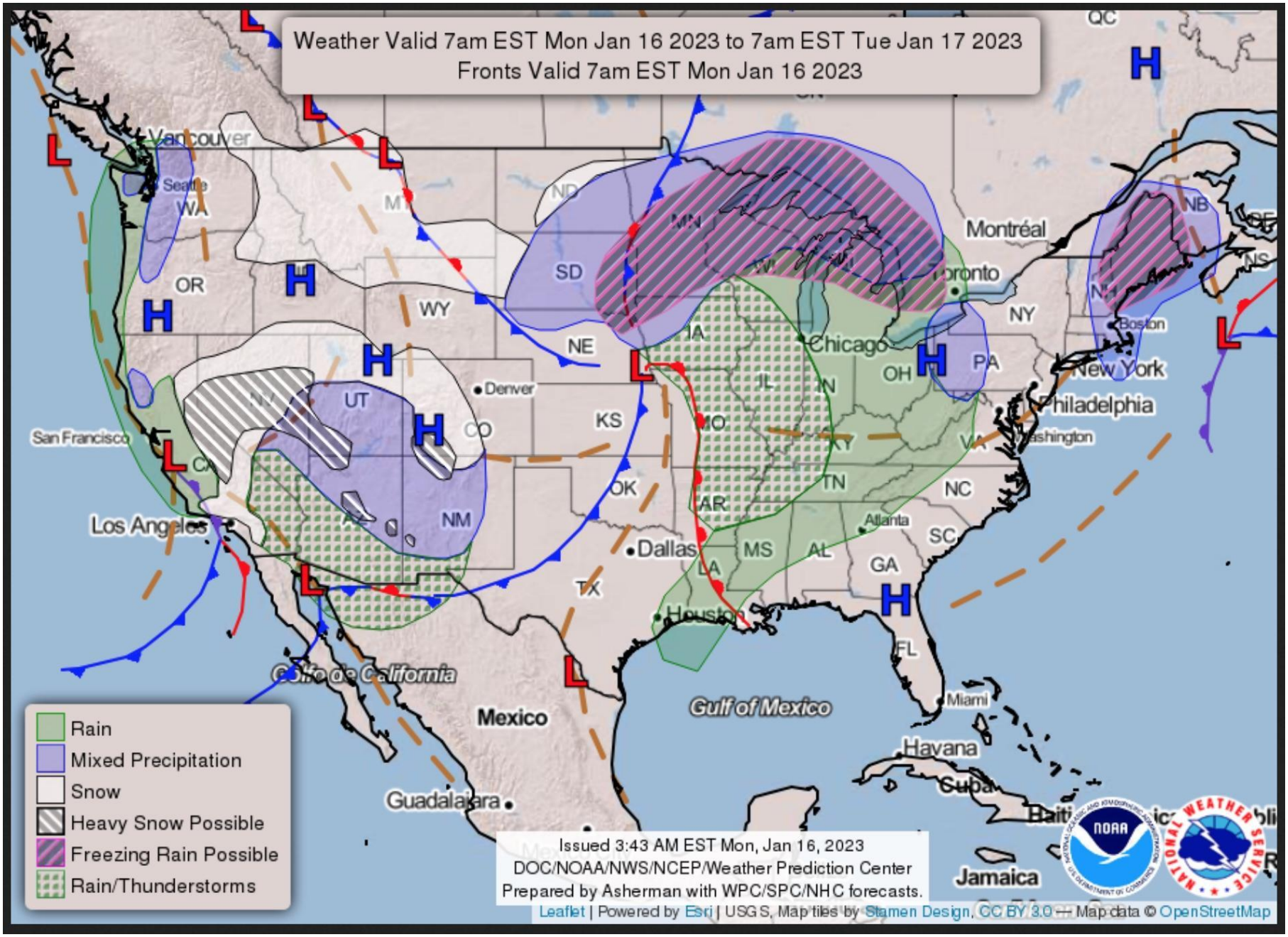



0000Z SURFACE ANALYSIS
DATE: TUE JAN 17 2023
ISSUED: 0142Z TUE JAN 17 2023
BY WPC ANALYST PUTNAM
COLLABORATING CENTERS: WPC, NHC, OPC


Weather Valid 7am EST Mon Jan 16 2023 to 7am EST Tue Jan 17 2023
Fronts Valid 7am EST Mon Jan 16 2023
Rain
Mixed Precipitation
Snow
Heavy Snow Possible
Freezing Rain Possible
Rain/Thunderstorms
Issued 3:43 AM EST Mon, Jan 16, 2023
DOC/NOAA/NWS/NCEP/Weather Prediction Center
Prepared by Asherman with WPC/SPC/NHC forecasts.
Leaflet | Powered by Esri | USGS, Map tiles by Stamen Design, CC BY 3.0 — Map data © OpenStreetMap
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Dallas
Houston
Chicago
Toronto
Montréal
New York
Philadelphia
Boston
Atlanta
Miami
Havana
Cuba
Jamaica
Mexico
Gulf of Mexico
Golfo de California
Guadalajara
WA
OR
CA
NV
ID
MT
WY
UT
AZ
CO
NM
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OH
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MS
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GA
FL
SC
NC
VA
PA
NY
NH
NB
NS
QC
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Sources of Weather Forecasts

- National Weather Service Marine Forecast
  - www.weather.gov/marine
  - Also available for mobile devices mobile.weather.gov
  - A long list of government sources for weather
- NOAA Weather Radio
  - WX on your VHF radio
- Commercial Products (based on NOAA and other models)
  - Available over your hotspot or StarLink
  - Examples: SailFlow, Windy, Predict Wind, mobileGrib

Weather Predictions

- Models
  - GFS
  - ECMWF
  - HRR
  - outputs of models are gridded, and have temporal and spatial resolutions.

- Are models in disagreement or changing over time?
  - Not unusual for models to significantly disagree 2.5+ days out
  - Usually there is convergence 24 hours out

Weather Predictions

- NOAA
  - Marine forecasts
  - Near-term forecasts and analyses
  - Longer-term outlook
  - Includes marine forecasts
  - Also: currents
- Use e.g. Windy to look at NOAA and other models
  - Not unusual for models to significantly disagree 2.5+ days out
  - Usually there is convergence 24 hours out

Questions?

An alternate weather forecast...

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Day sailing - off your mooring and back

- A few days out
  - Use Windy to look at the models to see if ti might be a nice day
  - Read the extended forecast discussion at NOAA
  - Realize that if it’s more than 4 days out the forecasts will be wrong.

Day sailing - off your mooring and back

- A few hours before:
  - Look at the local radar and forecast on your local TV station
  - Look at e.g Windy
  - Keep an eye on the lightning app

Day sailing - off your mooring and back

- During the sail:
  - Keep an eye out
  - Look at the weather radar on your phone
  - Look at the lightning app on your phone

You don’t want to be caught out. An afternoon at the Sail Loft beats an afternoon thunderstorm on a boat.

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ECDIS (Electronic Chart Display and Information System) break

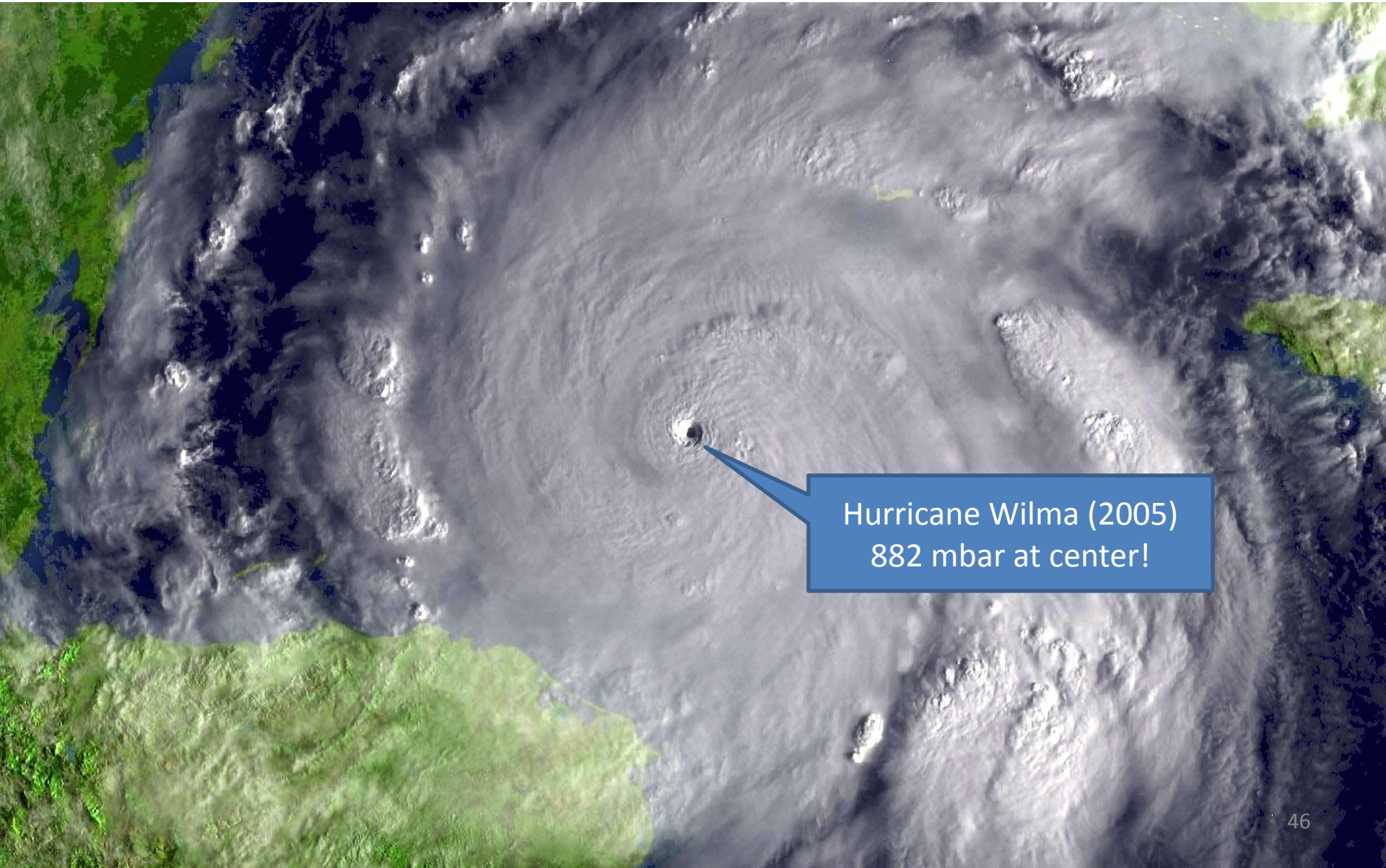
So you want to go to Bermuda?

- Start looking at the weather weeks before
- Pay close attention to the tropical disturbances https://www.nhc.noaa.gov/gtwo.php?basin=atlc&fdays=7
- Low long will it take you to get there?
- Load the gribs and use a routing package
- Do load the wave forecasts

Fair Winds and Following Seas!

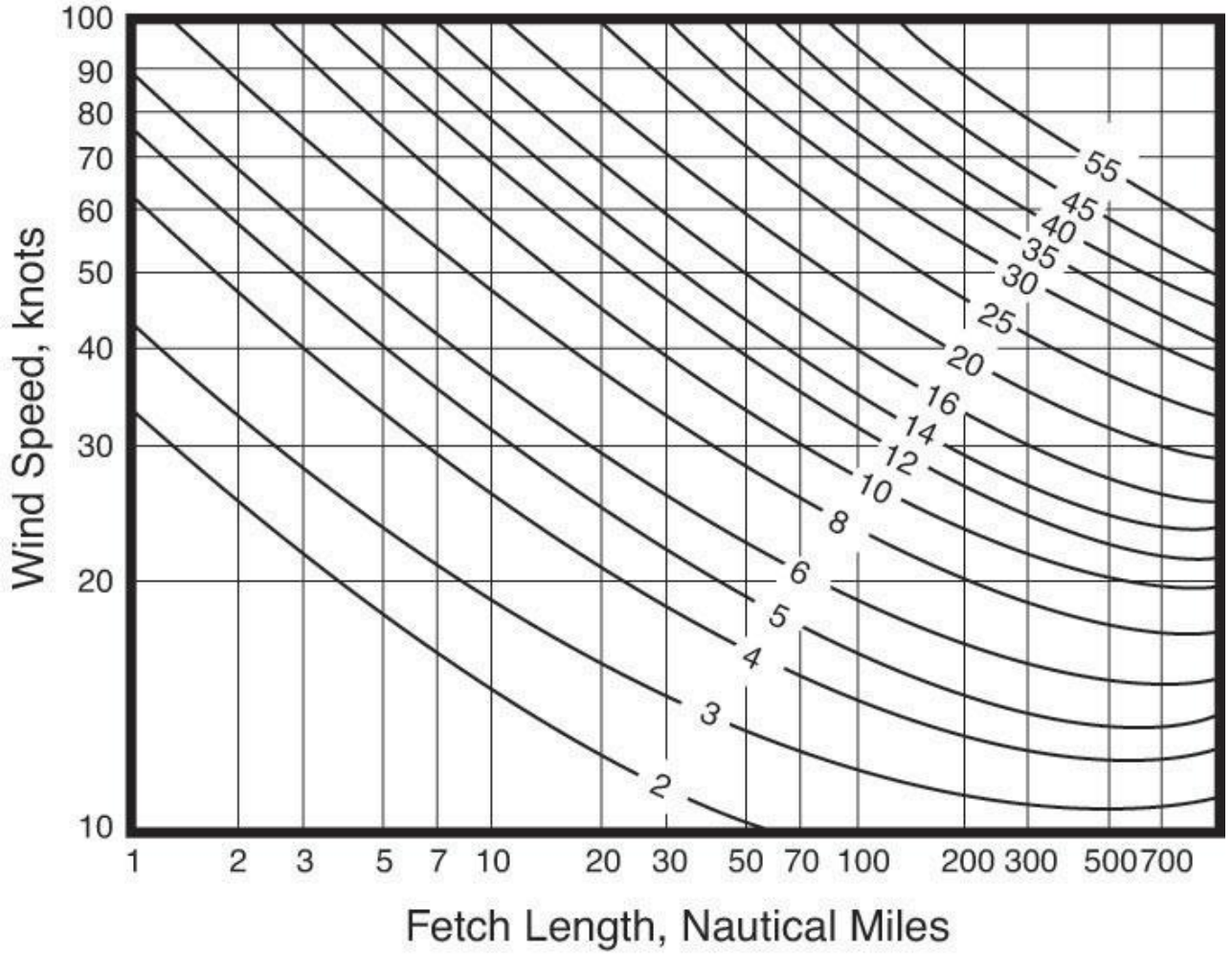
Questions?

Falling barometer = a Low is coming



Winds, Waves and Warnings

The greater the wind and the fetch, the higher the wave:



Force 0: Wind Speed less than 1 knot

Sea: Sea like a mirror

Force 1: Wind Speed 1-3 knots

Sea: Wave height .1m (.25ft); Ripples with appearance of scales, no foam crests

Force 2: Wind Speed 4-6 knots

Sea: Wave height .2-.3m (.5-1 ft); Small wavelets, crests of glassy appearance, not breaking

Force 3: Wind Speed 7-10 knots

Sea: Wave height .6-1m (2-3 ft); Large-wavelets, crests begin to break, scattered whitecaps

Force 4: Wind Speed 11-16 knots

Sea: Wave height 1-1.5m (3.5-5 ft); Small waves becoming longer, numerous whitecaps

Force 5: Wind Speed 17-21 knots

Sea: Wave height 2-2.5m (6-8 ft); Moderate waves, taking longer form, many whitecaps, some spray

Force 6: Wind Speed 22-27 knots

Sea: Wave height 3-4m (9.5-13 ft); Larger waves forming, whitecaps everywhere, more spray

Force 7: Wind Speed 28-33 knots

Sea: Wave height 4-5.5m (13.5-19 ft); Sea heaps up, white foam from breaking waves begins to be blown in streaks along direction of wind

Force 8: Wind Speed 34-40 knots

Sea: Wave height 5.5-7.5m (18-25 ft); Moderately high waves of greater length, edges of crests begin to break into spindrift, foam is blown in well marked streaks

Force 9: Wind Speed 41-47 knots

Sea: Wave height 7-10m (23-32 ft); High waves, sea begins to roll, dense streaks of foam along wind direction, spray may reduce visibility

Force 10: Wind Speed 48-55 knots (storm)

Sea: Wave height 9-12.5m (29-41 ft); Very high waves with overhanging crests, sea takes white appearance as foam is blown in very dense streaks, rolling is heavy and shocklike, visibility is reduced.

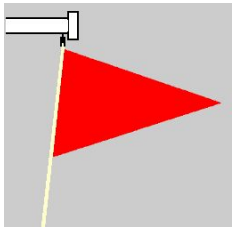
Force 11: Wind Speed 56-63 knots

Sea: Wave height 11.5-16m (37-52 ft); Exceptionally high waves, sea covered with white foam patches, visibility still more reduced

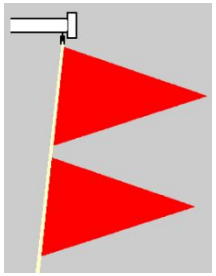
Winds, Waves and Warnings

Warnings

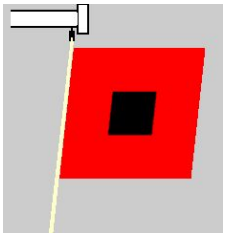
- Small craft advisory: forecast winds of 25 kts to 33 kts (no guidance on what a ‘small craft’ is)



- Gale warning: forecast winds of 34 kts to 47 kts



- Storm warning: forecast winds of 48 kts to 63 kts



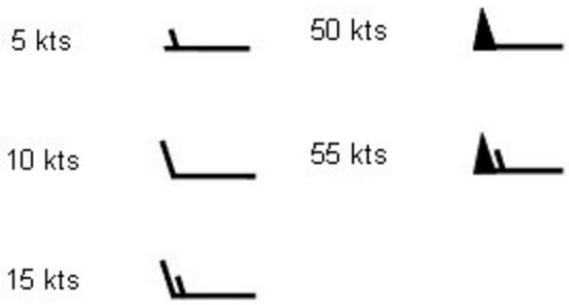
Wind and Waves

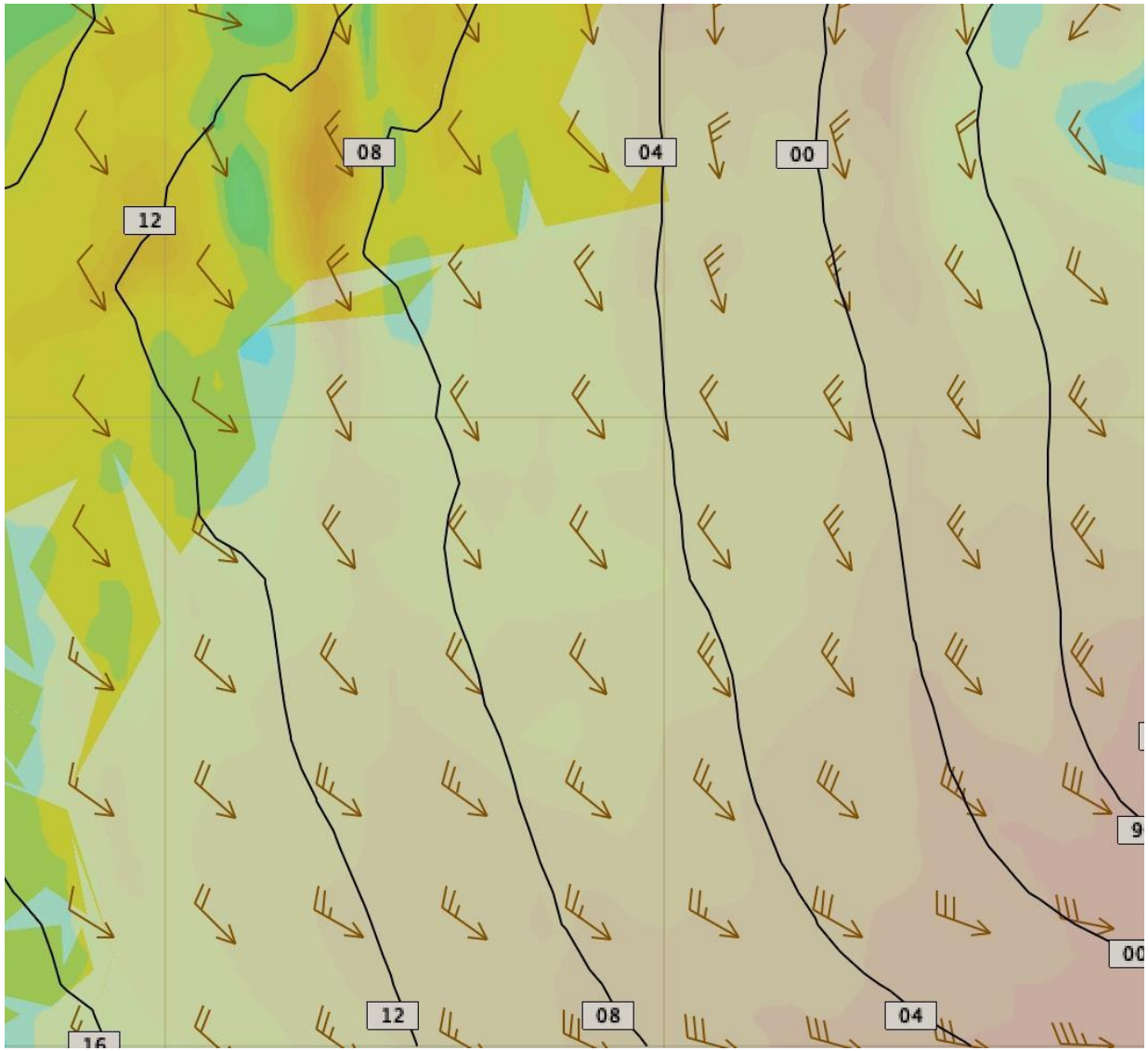
- Falling barometer
  - Millibars (mb or mbars) typically 1013.25 mbar
  - Falling 4 mb in 3 hours, expect winds 20+ knts
  - Falling 6 mb in 3 hours, expect gale-force winds!

Wind, Waves and Warnings

Wind comes from differences in pressure, and at the surface flows almost along the pressure isobars (due to the Coriolis force).

Direction and speed is represented on charts via a **wind barb**; the barb 'points' in the direction the wind is going.





OpenCPN to Bermuda

1/16/24

Sandy Wells

outline

in the next few slides I will summarize

weather routing
get grib files
load them into openCPN
browse grib data
configure route planner
plan route
browse route
browse report

weather routing

given predicted weather: wind waves current

and a model of the boat's performance

‘polars’

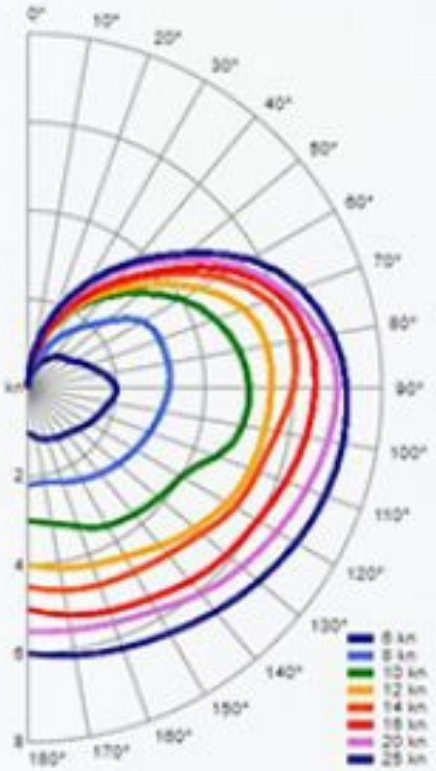
start time

search for optimum route from, e.g.,

cape cod to bermuda

polars

e.g. separate polars for spinnaker or not



	A	E	F	G	H	I
1	TWA\TWS	10	12	14	16	20
2	0	0.0	0.0	0.0	0.0	0.0
3	45	3.0	3.2	3.5	3.6	4.0
4	60	4.0	4.5	5.0	5.3	5.5
5	75	4.7	5.4	6.0	6.3	6.5
6	90	5.0	5.5	6.0	6.5	7.0
7	105	4.8	5.4	5.6	6.3	6.8
8	120	4.0	5.2	5.4	6.0	6.5
9	135	3.8	4.8	5.0	5.8	6.2
10	150	3.6	4.4	4.8	5.5	5.8
11	165	3.2	4.2	4.7	5.3	5.6
12	180	3.0	4.0	4.5	5.0	5.5
13						

Boat Polar and Spreadsheet

algorithms, software

- **Isochrone method**: Plots isochrones, or points that can be reached at a certain time, to determine the best strategy

Software

openCPN: free, does the job

expedition: used by pro ocean racers $1.5K

predict wind: popular, can run in cloud

smoother user interface, nice on IPAD

Get current GRIB predictions from saildocs.com

Email these messages to: querey@saildocs.com

Separate emails, no subject line, nothing else, is fragile

gfs:32N,43N,64W,72W|0.5,0.5|0,3..240|WIND,WAVES

rtofs:32N,43N,64W,72W|0.5,0.5|0,3..240|CURRENT

These specified which product, latitude - longitude range, .5 degree grid, 240 hours

Need cell phone or sat coms (iridium, starlink?)

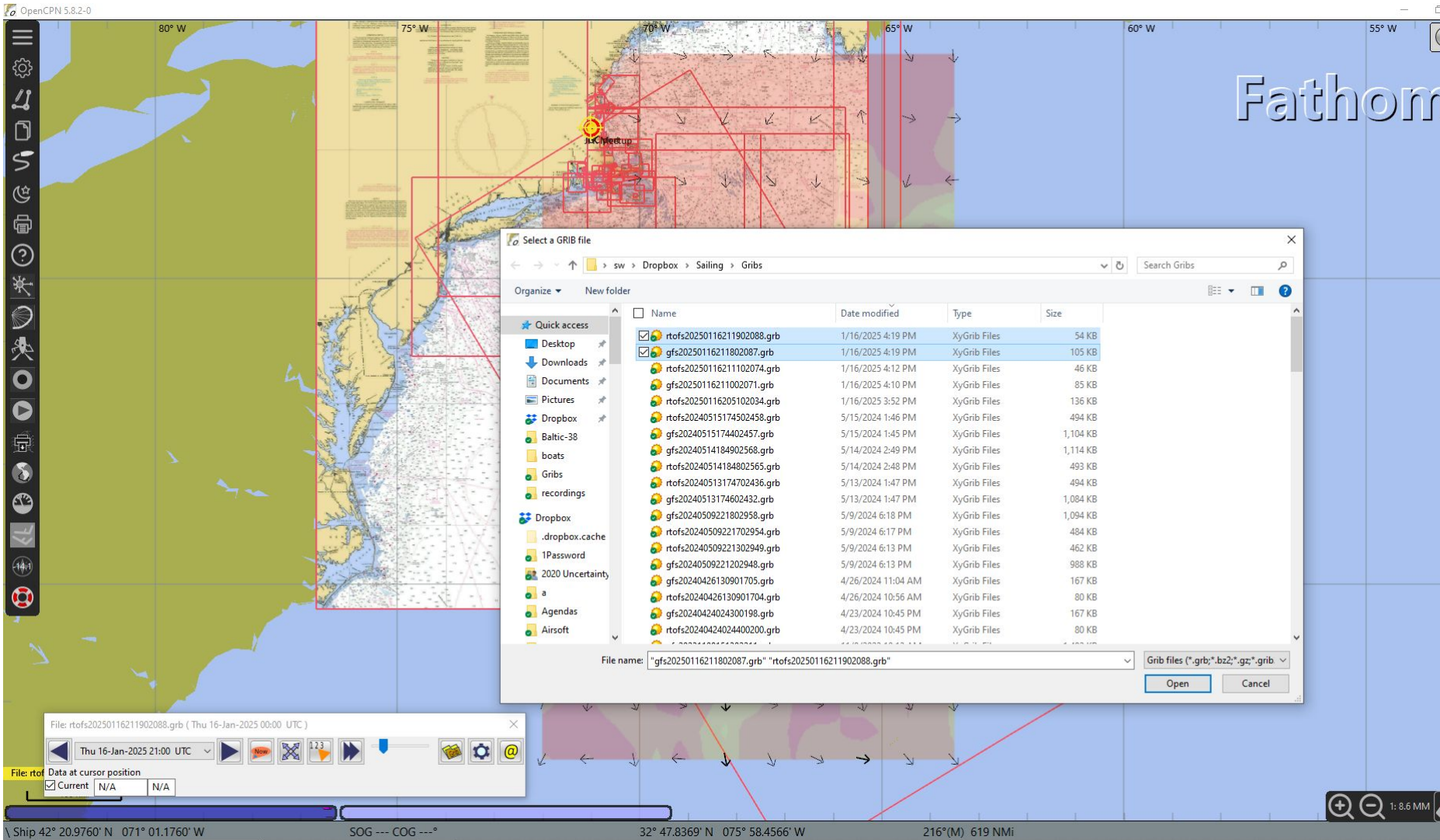
Receive grib files by email

Download them

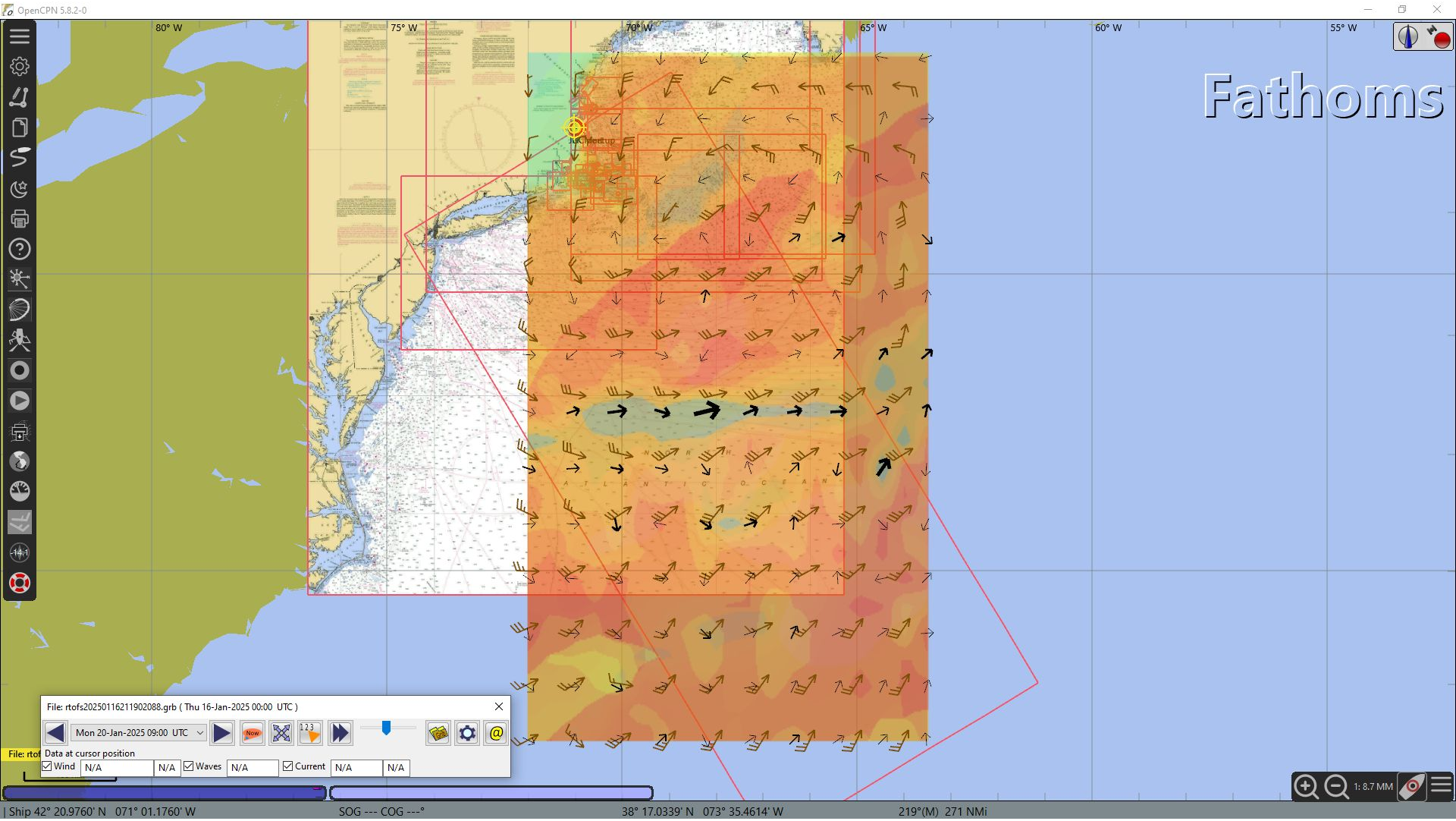
Start up *openCPN* grib feature

Load *both* files at the same time

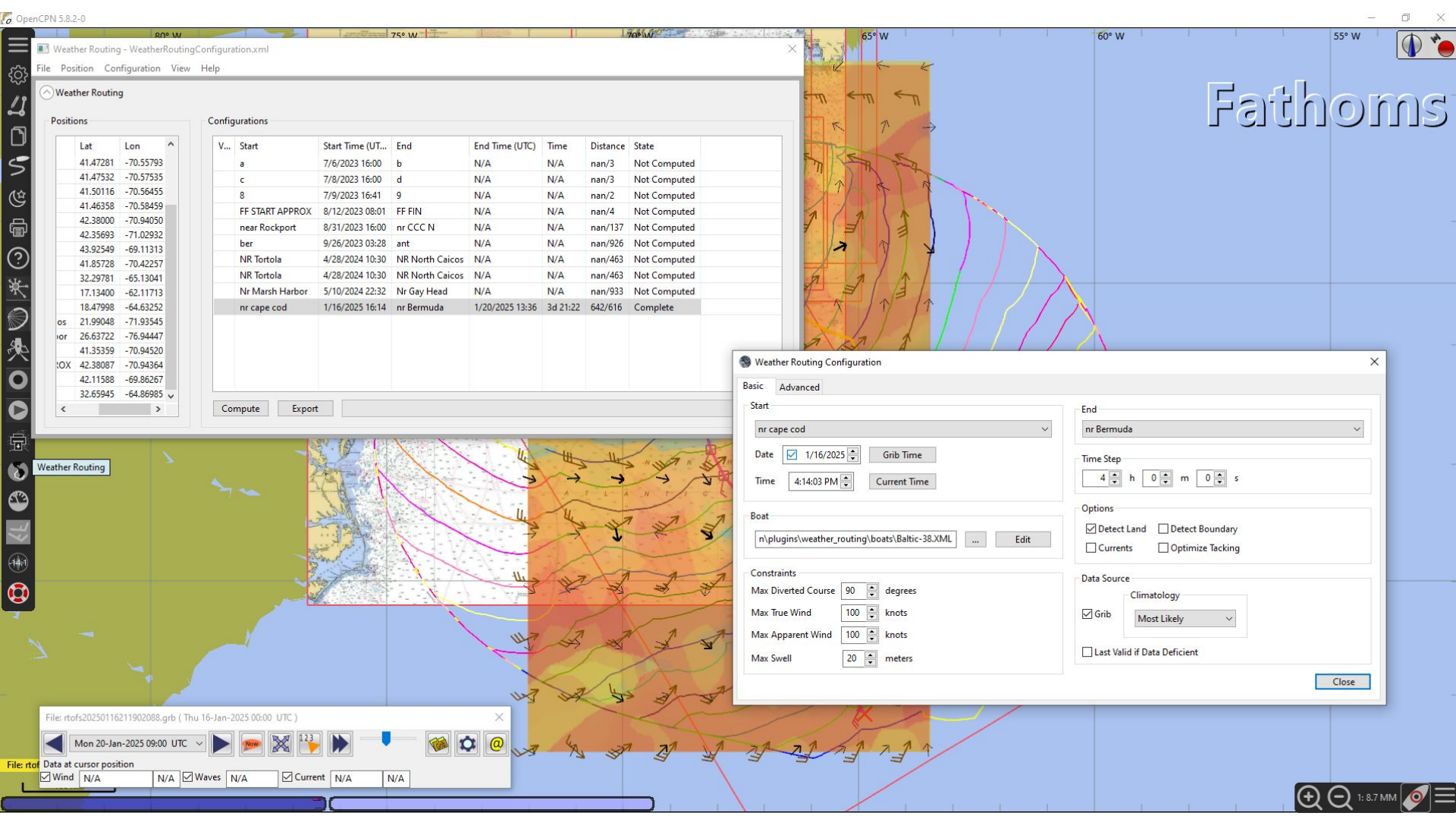
Load Gribs into OpenCPN



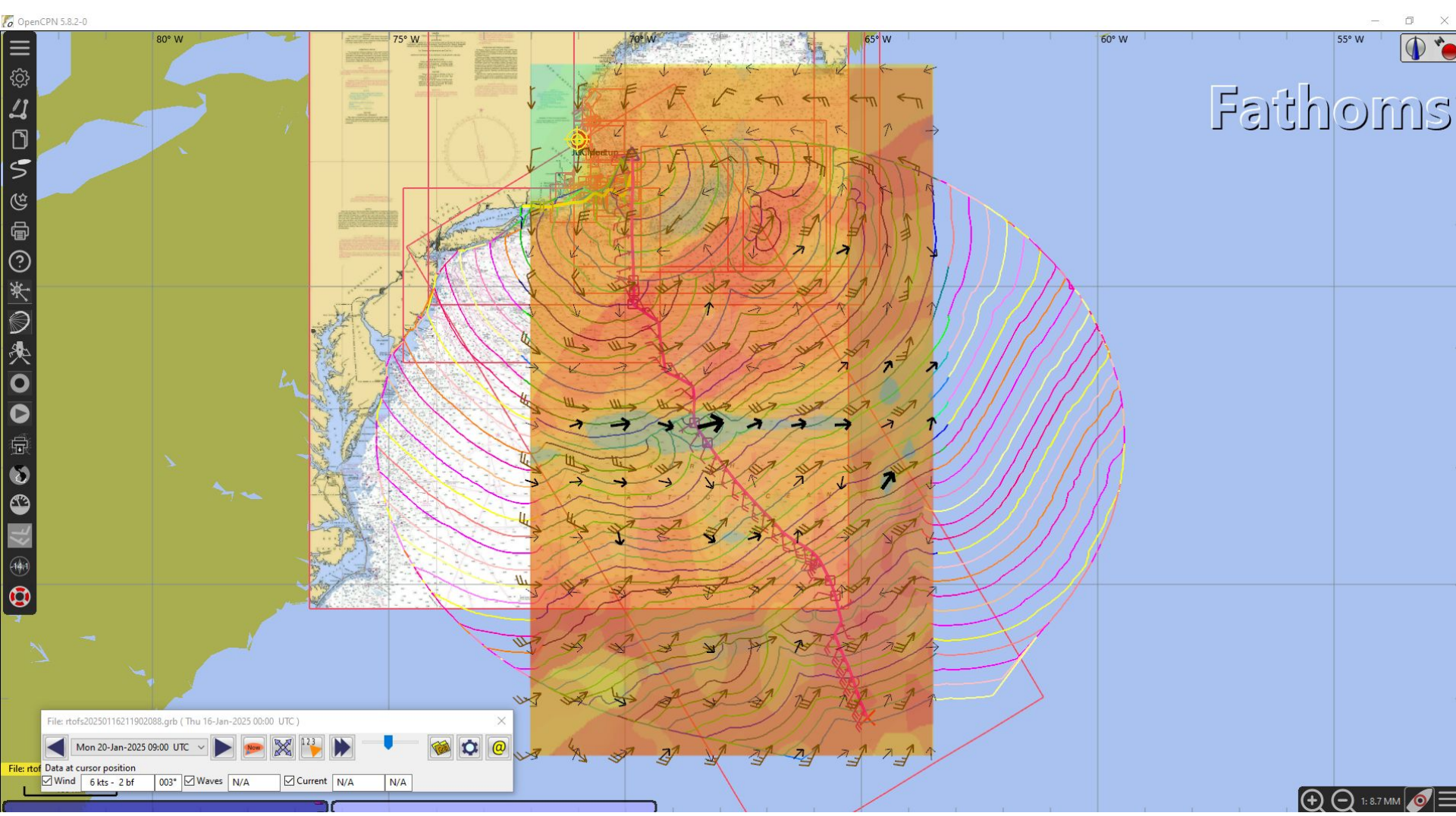
Browse gribs


OpenCPN 5.8.2-0
80° W
75° W
70° W
65° W
60° W
55° W
Fathoms
JKC head up
File: rtofs20250116211902088.grb (Thu 16-Jan-2025 00:00 UTC)
Mon 20-Jan-2025 09:00 UTC
Data at cursor position
Wind
N/A
N/A
Waves
N/A
Current
N/A
N/A
1: 8.7 MM
Ship 42° 20.9760' N 071° 01.1760' W
SOG --- COG ---°
38° 17.0339' N 073° 35.4614' W
219°(M) 271 NMi

Configure and run planner


OpenCPN 5.8.2-0
Weather Routing - WeatherRoutingConfiguration.xml
File Position Configuration View Help
Weather Routing
Positions
Lat Lon
41.47281 -70.55793
41.47532 -70.57535
41.50116 -70.56455
41.46358 -70.58459
42.38000 -70.94050
42.35693 -71.02932
43.92549 -69.11313
41.85728 -70.42257
32.29781 -65.13041
17.13400 -62.11713
18.47998 -64.63252
21.99048 -71.93545
26.63722 -76.94447
41.35359 -70.94520
42.38087 -70.94364
42.11588 -69.86267
32.65945 -64.86985
Configurations
V... Start Start Time (UT... End End Time (UTC) Time Distance State
a 7/6/2023 16:00 b N/A N/A nan/3 Not Computed
c 7/8/2023 16:00 d N/A N/A nan/3 Not Computed
8 7/9/2023 16:41 9 N/A N/A nan/2 Not Computed
FF START APPROX 8/12/2023 08:01 FF FIN N/A N/A nan/4 Not Computed
near Rockport 8/31/2023 16:00 nr CCC N N/A N/A nan/137 Not Computed
ber 9/26/2023 03:28 ant N/A N/A nan/926 Not Computed
NR Tortola 4/28/2024 10:30 NR North Caicos N/A N/A nan/463 Not Computed
NR Tortola 4/28/2024 10:30 NR North Caicos N/A N/A nan/463 Not Computed
Nr Marsh Harbor 5/10/2024 22:32 Nr Gay Head N/A N/A nan/933 Not Computed
nr cape cod 1/16/2025 16:14 nr Bermuda 1/20/2025 13:36 3d 21:22 642/616 Complete
Compute
Export
Weather Routing
Fathoms
65° W
60° W
55° W
Weather Routing Configuration
Basic
Advanced
Start
nr cape cod
Date 1/16/2025
Grib Time
Time 4:14:03 PM
Current Time
End
nr Bermuda
Time Step
4 h 0 m 0 s
Boat
n\plugins\weather_routing\boats\Baltic-38.XML
...
Edit
Options
Detect Land
Detect Boundary
Currents
Optimize Tacking
Constraints
Max Diverted Course 90 degrees
Max True Wind 100 knots
Max Apparent Wind 100 knots
Max Swell 20 meters
Data Source
Grib
Climatology
Most Likely
Last Valid if Data Deficient
Close
File: rtofs20250116211902088.grb (Thu 16-Jan-2025 00:00 UTC)
Mon 20-Jan-2025 09:00 UTC
Data at cursor position
Wind N/A N/A Waves N/A Current N/A N/A
1: 8.7 MM

Browse plan


OpenCPN 5.8.2-0
80° W
75° W
70° W
65° W
60° W
55° W
Fathoms
File: rtofs20250116211902088.grb (Thu 16-Jan-2025 00:00 UTC)
Mon 20-Jan-2025 09:00 UTC
Data at cursor position
Wind
6 kts - 2 bf
003°
Waves
N/A
Current
N/A
N/A
1: 8.7 MM

View report

Current Configuration

Boat Filename Baltic-38
Route from nr cape cod to nr Bermuda
Leaving 1/16/2025 4:14:03 PM
Arriving 1/20/2025 3:33:25 PM
Duration 95:19:22

Distance sailed: 663.26 NMi : 47.17 NMi or 7.66% longer than great circle route
Average Speed Over Water (SOW): 6.94 knots
Average Speed Over Ground (SOG): 6.94 knots
Average Wind: 17.99 knots
Maximum Wind: 37.85 knots
Average Swell: 2.24 meters
Upwind: 66.67%
Port/Starboard: 12/88
Number of tacks: 1
Sailing comfort: Difficult

Routes

nr cape cod to nr Bermuda (1 configurations)
Fastest configuration 1/16/2025 4:14:03 PM avg speed: 6.94 knots
Best Times (mostly downwind): none
Best Sailing Comfort: Difficult on 1/16/2025 4:14:03 PM
Cyclones: none
Start times for cyclone safe routes: 1/16/2025