Questions covering the Lecture Marine Meteorology 2022/23

- What drives the General Circulation ?
  - ✓ Solar radiation
    - ✓ Earth as a sphere
    - ✓ Slant Earth axis
    - ✓ Resulting meridional Temperature Gradient
    - ✓ Which are the main characteristics of the Coriolis Force?
  - ✓ Increases with latitude, Zero at Equator
  - ✓ Proportional to windspeed,
  - ✓ Perpendicular to windspeed: NHem to right, SHem to left
  - ✓ How many Circulation Cells form the Global Circulation?
  - ✓ 3: Hadley Cell Ferrell Cell Polar Cell
- What is the wavenumber of the Global Circulation? Which are its characteristics?
  - ✓ Wavenumber is the number of Ridge-Trough-Patterns over the Hemispheric circle
  - ✓ The higher the wavenumber, the shorter the wave, the faster its propagation eastward
  - ✓ Wavenumber n = 4 (Rossby wavelenght) is stationary
  - ✓ Wavenumbers n < 4 become retrograde (propagate to the West)
- Which are the Energetic characteristics of the Global Circulation?
  - ✓ Available Potential Energy APE of Zonal Flow is driven by diabatic solar heating
  - ✓ APE feeds Zonal Kinetic Energy by meridional temperature gradient
  - ✓ APE feeds APE-Eddies by warm air poleward / cold air equatorward
  - ✓ APE-Eddy feed Kinetic Energy Eddies by vertical motion inside eddies
  - ✓ Kinetic Energy Eddies dissipates by friction
  - ✓ Kinetic Energy Zinal Flow dissipates by friction
  - ✓ What is the geostrophic Wind?
  - ✓ Balance of Pressure Gradient and Coriolis Force
- What changes the wind as well?
  - ✓ Curvature of Isobars (gradient wind):
    - ✓ Higher windspeed in anticyclonic curvature (supergeostrophic)
    - ✓ Coriolis and Pressure gradient act in the same direction
  - ✓ Friction in the Bounday Layer

- How is the visibility defined?
    - ✓ When the contrast between a white and black target goes below 5 %
- Why is the temperature decreasing with height?
    - ✓ Air exerts expansion work against decreasing Pressure.
    - ✓ Where is it colder at a height of 15 km? Over the North Pole or over the Equator?
    - ✓ Over the Equator, because over the Polar region, the stratospheric temperature regime above the Tropopause with constant temperature, starts at 6 km (Height of Polar Tropopause).

The Height of the Tropical Tropopause is 18 km.

- What determines the Height of a Pressure Level, e.g. 500 hPa?
    - ✓ The average Temperature of the Layer and only this average temperature.
    - ✓ Which are the most common types of a temperature inversion?
    - ✓ Radiative Inversion (due to near surface radiative cooling during sky clear nights)
    - ✓ Subsidence Inversion (due to large scale subsidence, e.g. Azores High)
    - ✓ Upslide Inversion (due to warm air advection associated with warm fronts)

- How do Cyclones develop
    - ✓ 1. Baroclinic situation (i.e. horizontal temperature gradient)
    - ✓ 2. Upper Air flow pattern: Pre-Trough Area with high level divergence

- What causes the Sea breeze?
    - ✓ Warming of shoreline due to solar radiation, rising of pressure levels, horizontal pressure gradient at 1500m offshore, towards sea). Later onshore wind near surface due to local circulation
    - ✓ When do we have coastal convergence / divergence associated with onshore/offshore winds?
    - ✓ We have convergence with onshore winds and divergence with offshore winds. The reason is the Coriolis force, with turns the wind accordingly due to different friction over land / water.
- Which are the main types of Fog?
    - ✓ Radiation Fog: Radiative cooling of surface and subsequent fog forming
    - ✓ Advective Fog: Advection of moist (warm) air over cold surface, both over land and over sea (Newfoundland Banks. Sea Fog)
    - ✓ Mixing Fog: Mixing of two airmasses, both close to saturation, but not condensated yet.

- ✓ After mixing, immediate condensation takes place (forming of fog) due to over-saturation
- ✓ Upslide Inversion (due to warm air advection associated with warm fronts)

- Which GWS is characterized by unsteady weather, rain at time, mostly cloudy?
  - ✓ Type cyclonic from westerly directions SWz Wz NWz
  - ✓ Which GWS is characterized by dry weather, mostly sunny, no rain?
  - ✓ Type anti-cyclonic from easterly directions NEz Ez Sez
- Which GWS is characterized by dry and hot / cold weather in summer / winter?
  - ✓ Type anti-cyclonic from easterly directions NEz Ez Sez
- What is the typical beginning of a TS over the North Atlantic?
  - ✓ Easterly Wave moving from W-Africa eastward
  - ✓ Which are necessary preconditions for TS development?
  - ✓ 1. Water Temperature Tw or Sea Surface Temperature SST > 27°C to bring sufficient latent energy by evaporation into the atmosphere
  - ✓ 2. Geographical latitude Lat > 5°N to allow development of circulation
  - ✓ … Unstable vertical stratification to allow vertical development
  - ✓ … Low vertical windshear VWS to allow vertical development of circulation
- When is the ‚Hurricane Season' in general and for the North Atlantic in particular
  - ✓ Late summer in general, July for North Atlantic
  - ✓ June – too soon; July – stand by; August – a must; September – remeber; Oct – all over
- How are tropical Storms categorized?
  - ✓ Encountered / Estimated winds
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  - ✓ Tropical Depression TD Bft.7 or less 33 kt or less
  - ✓ Tropical Storm TS Bft.8 - Bft.11 34 kt – 63 kt
  - ✓ Hurricane Bft.12 64 kt or more
    - ✓ Hurricanes Categories
    - ✓ Saffir-Simpson 1 Minimal
    - ✓ Saffir-Simpson 2 Moderate
    - ✓ Saffir-Simpson 3 Extensive
    - ✓ Saffir-Simpson 4 Extreme
    - ✓ Saffir-Simpson 5 Catastrophic, Devastating

- What is the Monsoon ?
  - ✓ Monsoon is a Land – Seabreeze – Circulation with the following scales
  - ✓ Time scale: Months, Seasons (typical Land/Sea Breeze: one day)
  - ✓ Length scale: 1000s of kilometers (typical Land/Sea Breeze: 10s of km)
  - ✓ Seasonal Summer May-Aug Warm, moist, Heavy Rain over India (> 12.000mm/yr)
  - ✓ Seasonal Winter Mar-May Cold, dry air,
- How would you describe NWP?
  - ✓ NWP is an initial state problem, characterized by 6 equations (primitive equations, some of them time-dependent) for 6 variables (Pressure, Humidiy, density, 3 wind components) . These equations are computed for the future: forecast!
- What are typical resolutions (grid mesh-size) for NWP model?
  - ✓ Global tens of km, Regional (fine-mesh) a few km
- Which is the problem of the limited mesh-size
  - ✓ There are (sub-grid) phenomena that cannot be resolved by the model, e.g. shower, thunderstorm, land-sea-breeze, local valley winds. These phenomena are parameterized, i.e. decribed by formulas.
- What is required for numerical stable modelruns?
  - ✓ Compliance with the Courant-Friedrich-Lewy-condition
  - ✓ Ratio between mesh-size and timestep (violated by Richardson 1921)
- How can you improve forecasts based on the DMO (Direct Model Output)
  - ✓ By statistical post-processing. This covers adaptive filters (Kalman) and statistical post-processing, typical MOS (Model Output Statistics) and PP (Perfect Prog)
- What is the difference between MOS and Perfect Prog?
  - ✓ Both are based on multiple linear regression equations …
  - ✓ … MOS between observations and DMO Model Output field (typical 5 years)
  - ✓ … Perfect Prog between observations and Analyses only (typical 40 years)
- What are main Pros and Cons of both?
  - ✓ MS Pros: corrects systematic NWP errors,
  - ✓ MS-Pros: allows forecast of all observed parameters (not computed by the model though)
  - ✓ MS-Cons: Model-specific development, model changes have to be corrected for
  - ✓ PP-Pros: Information of 40 years is used
  - ✓ PP-Pros: Can be used for any model, not model-specific (Forecast considered Perfect, PP)

- ✓ PP-Cons: Can be used for any model, not model-specific: does not correct model errors

- What is the idea behind Ensemble Forecast Technology?
  - ✓ NWP models are sensitive against infinitesimal errors in the initial state, therefore 50 simplified model versions are run with infinitesimal changes of the initial state and the results are interpreted by 'clustering'
- What does the IR Greyscale of satellite images represent?
  - ✓ A temperature scale: black is warm, white is cold
- What is the intention of using multi-spectral channels
  - ✓ To get many neighbouring data from heights where the channel specific weighting-function has ist maximum to deduce a vertical profile information, typically a temperature profile
- What can be a problem with Radar in heavy precipitation?
  - ✓ Attenuation. The heavy precipitation inhibits signals from rain areas behind observed precipitation, which can be even more intense than the one detected (Aviation!)
- What is the advantage of Doppler Radar
  - ✓ It offers information about the relative speed of raindrops toward or away from the radar antenna thus allowing to retrieve windspeeds, windshear and even rotational windspeed patterns (Tornado)
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- How is the characteristic wave height defined?
  - ✓ The characteristic waveheight is the mean of the highest third of waves
- How many classes has the Beaufort Scale and what is its historic origin?

- ✓ The Beaufort Scale has been defined by Admiral Beaufort in the early 19th Century. It is related to the sails set on a tall sailship.
- ✓ The Beaufort Scale is divided into 13 classes INCLUDING BFT 0 = WIND CALM.
- ✓ The highest Beaufort Force is 12: 64 knots or more.
- ✓ There is NO (!) Beaufort 13!
- ✓ What is necessary to form wave heights called ‚mellow sea' ?
- ✓ Sufficient distance where the wind can interact with the sea (‚fetch') and, sufficient water depth and a sufficient time of the wind-sea-interaction

➢ What is the reason for breaking waves to develop near the beach?

- ✓ If the waterdepth decreases towards the beach, the wave propagation speed is defined by $\sqrt{g*h}$ The lower the depth, the slower the wave propagation – following waves ‚overtake' preceding ones thus ‚breaking' them

➢ What is the difference between sea and swell?

- ✓ Sea describes waves generated by the current wind field,
- ✓ Swell has been generated by wind in the past by another storm field at another place.
- ✓ It can have (and typically has) another direction than the current wind.

➢ What is a characteristic interaction between sea and swell, which maybe dangerous to sailors?

- ✓ Cross seas – superposition of waves with different directions

➢ What is the Ocean Global Conveyor belt?

- ✓ A global water circulation originating from sea ice forming in the Arctinc, which is associated with sinking of very salty (therefore higher density i.e. heavy) water (brine) – the ice formed is not salty!
- ✓ The Global Conveyor Belt extends all over the World and goes deep to the seafloor
- ✓ The typical time for a full cycle is thousands of years.
- ✓ What is the reason for areas of upwelling water near continental coasts?
- ✓ Wind blowing continuously parallel to the coast (Trade winds typically) with a resulting drift (transport) of surface water away from the coast thus triggering upwelling
- ✓ Why is the direction of transport of surface water not in wind direction?
- ✓ The Coriolis force deflects it to the right (NH!), 45° at surface, 90° upper layer down to 50m

➢ What is Westward intensification?

- ✓ Westward intensification describes the currents in oceanbasins, which have a higher velocity in the Western parts (e.g. Gulfstrean, Kuroshio). The reason is the Coriolis

Force and the fact, that the water is pushed westward by the easterly winds on the southern edge of subtropical anticyclones

- What causes Tides
  - ✓ The gravitational force of the moon
- When do spring tides and and dead tides occur?
  - ✓ Spring tides occur when Sun–Moon–Earth are in line, i.e. full moon / dead moon
  - ✓ Dead tides occur when Sun–Moon–Earth are in 90° angle, i.e. descent / crescent half moon
- What is an Amphidromic Point?
  - ✓ Amphidromic Point is a point around which the tidal currents flow and which has itself no tidal range.
- Which are typical values of salinity in Oceans?
  - ✓ 3 o/oo Baltic Sea (epicontinental sea)
  - ✓ 30 o/oo Oceans in general
  - ✓ 3 o/o equivalent value in percent
  - ✓ 30 o/o Dead Sea
- At which water temperature does sea ice form?
  - ✓ - 1.7 °C

- What is the effect of CO2 in the atmosphere? How can it be described?

  CO2 absorbs the outgoing longwave IR radiation thus warming the atmosphere. The effect can be described by the Climate sensitivity which describes the temperature increase in case of doubling CO2. The current CO2 level in the aztmosphere is approx. 420 ppm. The estimates of the climate sensitivity varies between 2K and 5 K. It has first been estimated in 1896 by the Swedish chemist Svante Arrhenius in exactly this range.

- What is the effect of increase of global temperature in terms of weather?

  The air temperature distribution can be described by the Gaussian distribution. An increase of the mean value has the following effects:

  1. Higher warm extreme values, which have not been observed before, will occur

  2. The frequency of warm extreme values observed in the past will increase (more cases)

  3. The frequency of cold extreme values observed in the past will decrease (less cases)

- Where does the Global Warming end up?
- More than 90 % in the Ocean, 2 % in the atmosphere