How to deal with coordinate systems in numerical weather models?
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Goals of the newly formed IAG SSG 12

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Introduction

Geodesists utilize

- Pressure
- Temperature or potential temperature
- Relative humidity or water vapor mixing ratio
- Wind speed and direction

from numerical weather models (NWMs) for various purposes (Atm. Loading, mapping functions, AAM, …).

Main issues when dealing with NWMs:

- Transform from meteorological height system to a geodetic one
- Deal with grids irregularly spaced in the vertical
- If not given on a regular (horizontal) grid then a transformation is necessary
- Latitude problem: geodetic vs. geocentric latitude
- What is the NWM topography and how does it relate to reality?

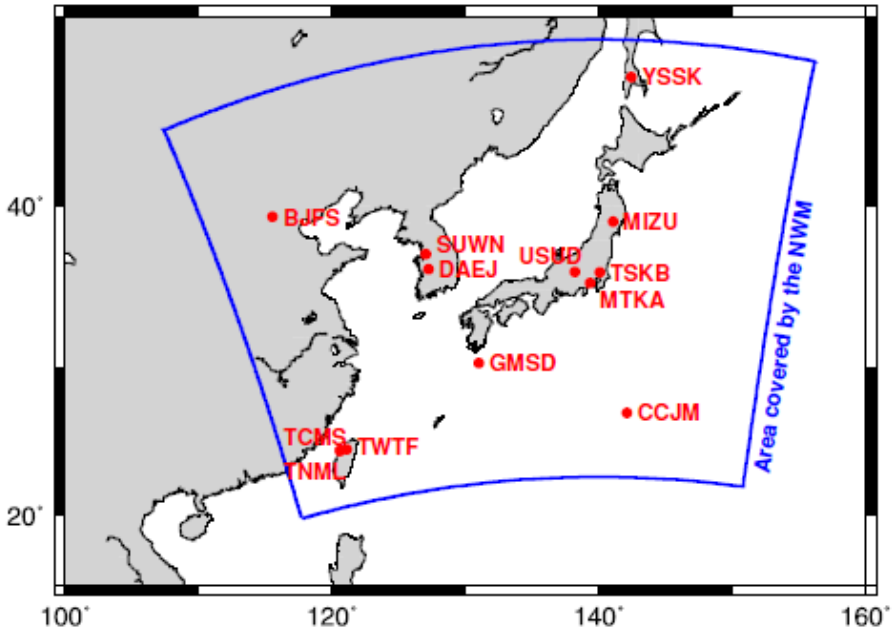
Goals of the IAG special study group 12

- Understand the horizontal coordinate systems of the different NWMs, ranging from global to small-scale regional models
- Understand the vertical coordinate systems of the different NWMs, ranging from global to small-scale regional models
- Formulate a clear mathematical description on how to transform between NWMs and a geodetic frame (in both directions)

As SSG formed just recently, we are going to discuss what we want to achieve …

Horizontal coordinate systems

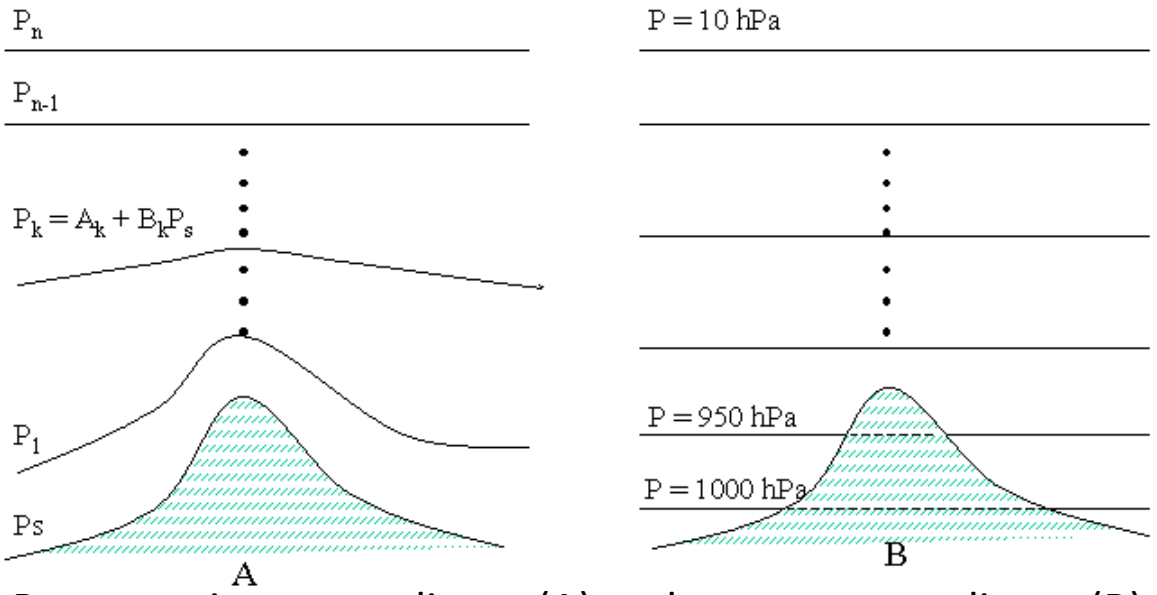
- Easy to handle when given on a (rectangular geographic grid. But see also latitude issue later.
- But how to treat “irregular” grids (map projections, etc.). Especially important when computing partial derivatives.
- Order of interpolation?
  - Horizontal → vertical
  - Vertical → horizontal
  - Full 3 D ?



Vertical coordinate systems

Mostly two height systems used in NWMs

- geopotential heights (claimed above “mean sea level”, and based on constant g = 9.80665 m/s^2)
  - Straightforward transformation to ellipsoidal heights (via geopotenial, standard gravity and geoid undulation)
- sigma-coordinates
  - Basically terrain following
  - Requires deep knowledge about the NWM



Pressure sigma coordinate (A) and pressure coordinate (B).

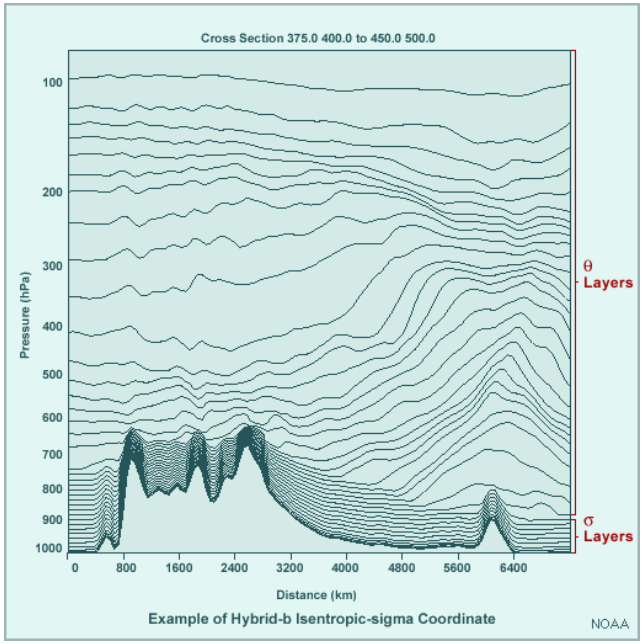
Yet NWM are typically made available discretized in isobars, but not regularly spaced in height. Needs pre-processing or more complicated interpolation.

Other vertical coordinate systems

In a few cases other vertical coordinate systems are used

- Eta coordinate (somewhat similar to geopotential heights)
- Theta coordinates (following potential temperature)
- Hybrid coordinates

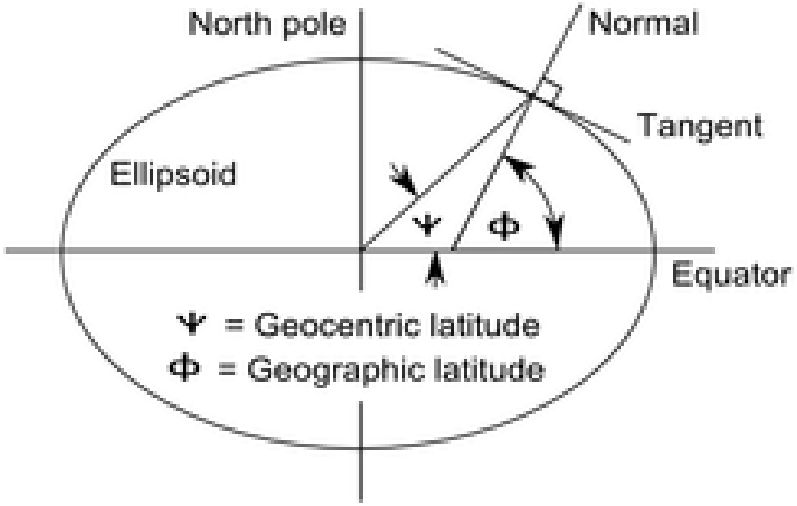
In all cases knowledge about the weather model physics is needed (outside scope of SG)



Hybrid coordinates

The latitude (geocentric vs. geodetic) problem

- NWMs computations are based on a spherical Earth
- Difference of up 0.1 degree $\rightarrow$ becomes an issue when going to fine-mesh models
- NS - asymmetry due to the Earth's flattening must be considered correctly



Topography

- Topography (GTOPO, ETOPO) taken from data based on geodetic latitudes, but used on a spherical Earth
- NWM topography usually smoothed (e.g. after spherical harmonics truncation)
- Topography mismatch (GPS station under mountain, etc…), important in regions of rapid topographic variation and/or rapidly changing meteorological conditions
- Coastline mismatch

Solution approach

- Theoretical: summarize our current understanding of MWM
- Practical: assess impact of competing formulations in terms of errors in atmospheric parameters and derived geodetic products (ray-traced tropospheric delays and mapping functions, loading and angular momentum)

Study group action items

- Provide consistent transformations from/to numerical weather models
- Provide routines (C/C++, Fortran, Matlab, …) for users
- Summarize the “recommendations” in a paper
- If enough time remains, investigate formal errors resp. error propagation of NWMs

NWMs considered for SSG studies

- ECMWF
- HIRLAM
- JMA
- NCEP
- Canadian model
- LAPS
- local and fine-mesh models (TBD)

You want to contribute or get more information ?

Check SSG homepage
http://hobiger.org/blog/iag-ic-ssg12/

Join us at our kick-off meeting next week

Wednesday, April 25th, 2012; 9:00 – 12:00,
Seminar room 124 (4th floor),
Vienna University of Technology,
Gusshausstrasse 27-29, 1040 Vienna, Austria

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Thank you very much for your attention.