Climate and Forecasting (CF) Conventions

7th Joint Earth Science Data System Working Group
Philadelphia

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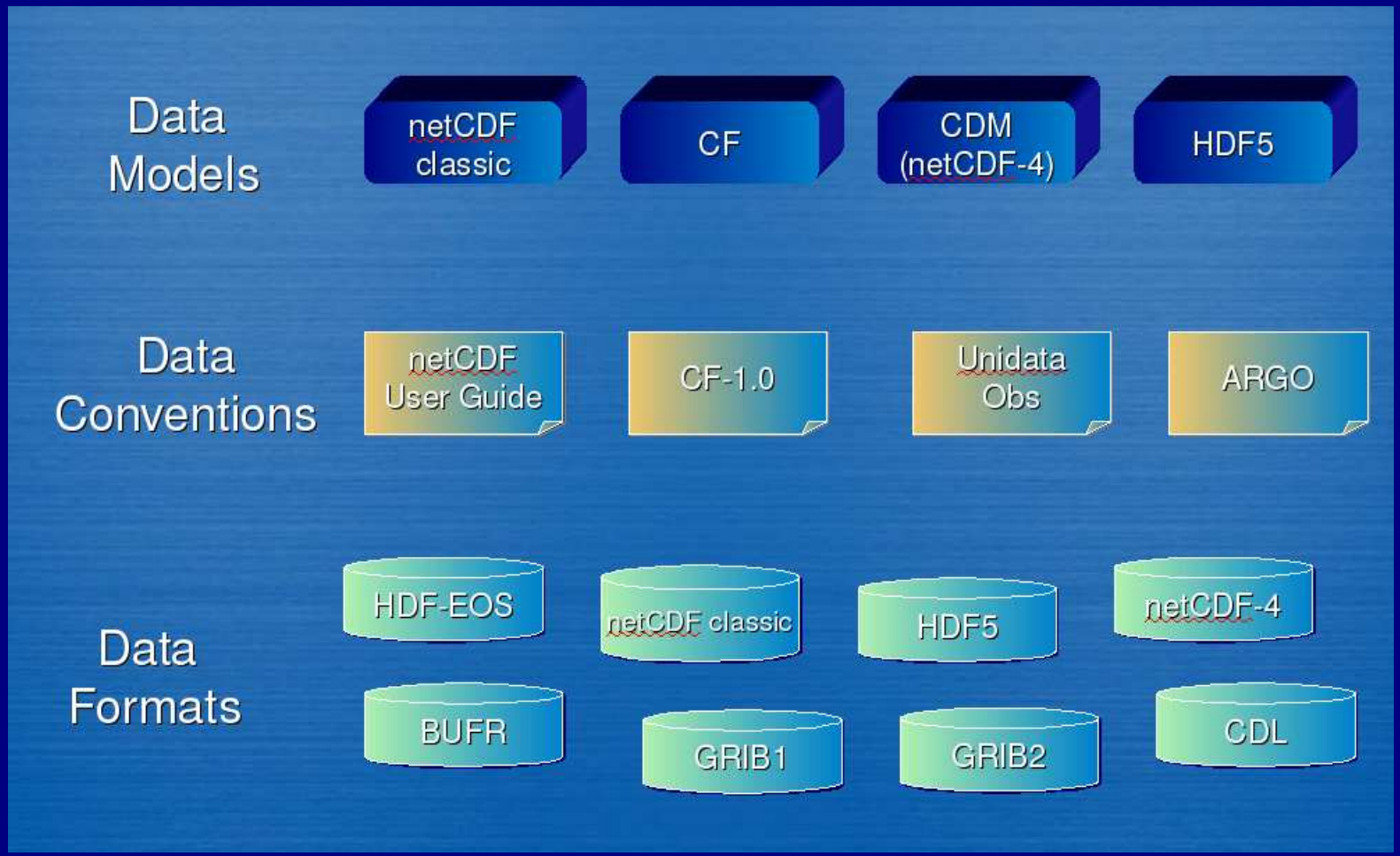
Talk outline. . .

1. What are the CF Conventions?
2. How widely used is CF metadata?
3. How were the CF Conventions developed?
4. How is CF governed?
5. Where is CF headed?
6. What's on the "Concluding Comments" slide?

Talk outline . . .

Formats, Conventions, Data Models



What are the CF Conventions?

- A standard for encoding Climate and weather Forecast metadata in netCDF files: `cfconventions.org`
- Metadata conventions supporting interoperability for earth science data from different sources
- Intended for both model output and observational datasets
- Examples of CF metadata
  - Coordinate information needed to locate data in space and time
  - Standard names for quantities to determine whether data from different sources are comparable
  - Additional grid information (e.g., grid cell bounds, cell averaging methods)

Goals of the CF Conventions

- Locate data in space-time and as a function of other independent variables, to facilitate processing and graphics
- Identify data sufficiently to enable users of data from different sources to decide what is comparable, and to distinguish variables in archives
- Framed as a netCDF standard, but most CF ideas relate to metadata design in general and not specifically to netCDF, and hence can be contained in other formats such as XML
- Backwards-compatible with prior standards: COARDS is a fully-contained subset, though some COARDS features are deprecated.

CF data descriptors

- Data provenance: `title`, `institution`, `contact`, `source` (e.g model), `history` (audit trail of operations), `references`, `comment`
- Description of associated activity: `project`, `experiment`
- Description of data: `units`, `standard_name`, `long_name`, `auxiliary_variables`, `missing_value`, `valid_range`, `flag_values`, `flag_meanings`
- Description of coordinates: `coordinates`, `bounds`, `grid_mapping` (with `formula_terms`); time specified with `reference_time` ("time since T0") and `calendar` attributes.
- `cell_methods`, `cell_measures`, and climatological statistics.

Talk outline . . .

Where is CF Metadata used?

- Widely used and accepted in the climate community
  - World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset, used by Intergovernmental Panel on Climate Change (IPCC) Working Group 1
  - Paleoclimate Modeling Intercomparison Project (PMIP), Hemispheric Transport of Air Pollution (HTAP), regional groups, EU-funded ENSEMBLES prediction system for climate change, ...
  - Planned use in model archives for next IPCC cycle (CMIP5/AR5)
- Widely adopted in other netCDF archives for atmosphere, oceans, and surface data: ESMF, GFDL, Hadley Centre, NCAR, NOAA, ...
- Supported by various software packages with facilities for analyzing, visualizing, subsetting, regridding, and aggregating data

Talk outline . . .

A brief history of CF

- Evolved from simple netCDF User Guide conventions (1989), COARDS standard (1995), GDT (1999), and NCAR CSM (1999) conventions
- 2000-2003: Developed by volunteer efforts (Brian Eaton, Jonathan Gregory, Bob Drach, Karl Taylor, and Steve Hankin)
- 2003: CF 1.0 released
- 2005: CF white paper discussing future governance circulated
- 2006: Revised white paper presented to WCRP WGCM
- 2007: Rules for community-initiated changes to CF conventions agreed upon

Guiding Principles of CF

- Data should be self-describing, without external tables needed for interpretation.
- Conventions should only be developed for things we know will be needed.
- Conventions should not be onerous to use for either data-writers or data-readers.
- Metadata should be readable by humans as well as easily interpretable by programs.
- Redundancy should be minimized to avoid inconsistencies when writing data.

Talk outline . . .

CF Governance Structure

- CF Governance Panel established
- Control turned over to two working committees:
  - CF Conventions
  - CF Standard Names
- Committee work done via email and archived web discussion at `cfconventions.org`
- WCRP/WGCM has been asked to assume responsibility for stewardship
- WCRP/WGNE has been invited to appoint representation on CF Governance Panel

Strengths of CF Governance

- Successful international collaboration to codify best practices into a community standard
- Proven record of achieving interoperability
- Engagement of diverse communities to capture expertise for standard names
- Agreement on open process for evolving conventions and reaching consensus
- Commitment of organizational infrastructure and resources
  - BADC: Standard names – (50% FTE)
  - LLNL PCMDI: Web site support – (20% FTE)
  - UCAR Unidata: Library development (`libcf`) – (10% FTE)
- Discussion of CF issues at annual GO-ESSP (Global Organization for Earth System Science Portals) meetings: `http://go-essp.gfdl.noaa.gov`

Issues with CF Governance

- How to get volunteers from community to help with
- Creating and reviewing proposals to address new technical issues
- Testing adequacy of proposed extensions
- How to balance desired simplicity versus necessary complexity?
- How to balance immediate needs of data providers versus stability needed by application developers?
- How to resist temptation to tinker, oversimplify, or over-generalize?
- Peaceful co-existence with other standards: OGC, MMI, . . .

Talk outline . . .

Future directions of CF

- Implementing CF metadata conventions for other file formats (besides netCDF)
- Supplying both data providers and application developers with library support for using CF
- Providing improvements for representing observational data and metadata
- Supporting more types of grids (staggered, curvilinear, nested)
- Supporting mappings between CF and other metadata standards and conventions
- Use of netCDF-4 data model and format

Some current hot ticket items in CF

Several complex proposals and projects are currently under active discussion on the lists:

- *Ensemble axis:* Representation of an ensemble of model runs.
- *Aggregation:* XML representations of netCDF (e.g NCML) allow an aggregated “dataset” view of sets of files.
- *Semantic mediation:* adding more semantic-web ideas to CF to reconcile differing vocabularies, express synonymity, supersession, subsumption.
- *Grid specification:* A richer syntax for grids to express mosaics, unstructured grids, etc.
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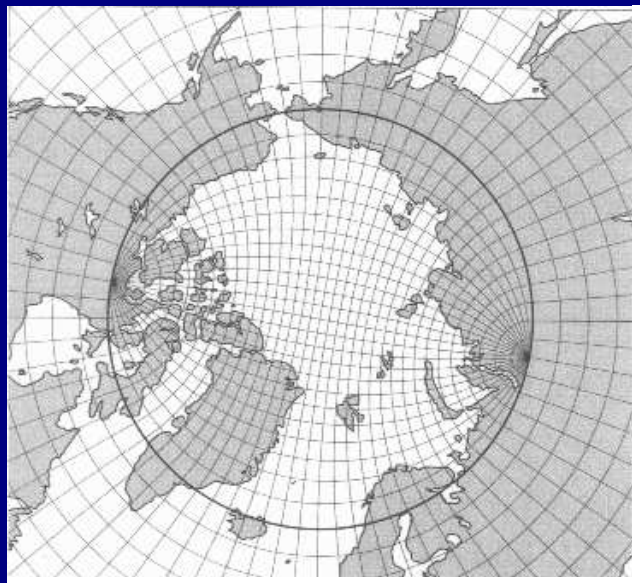
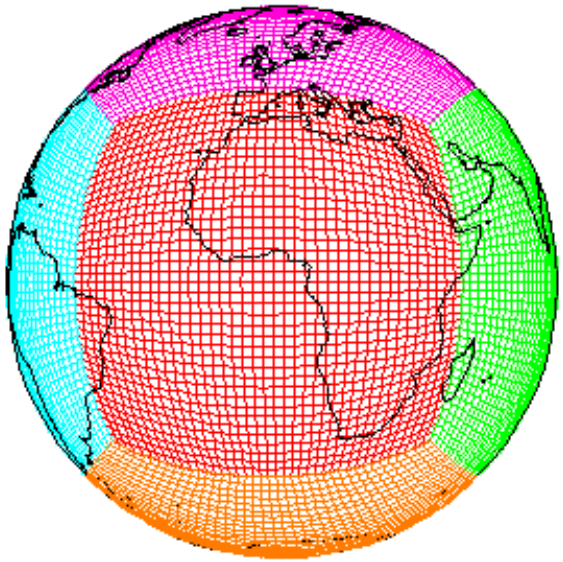
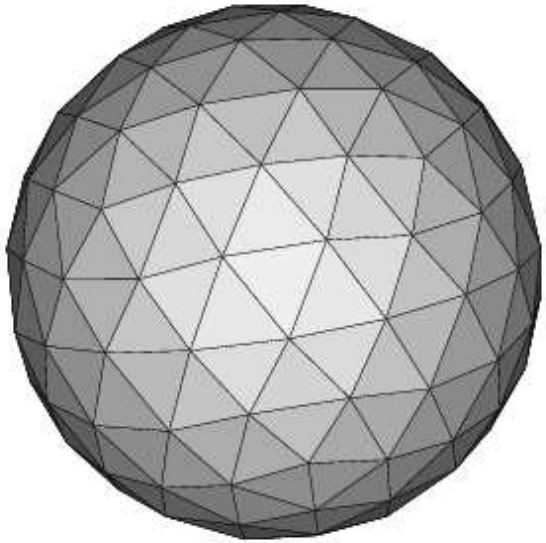
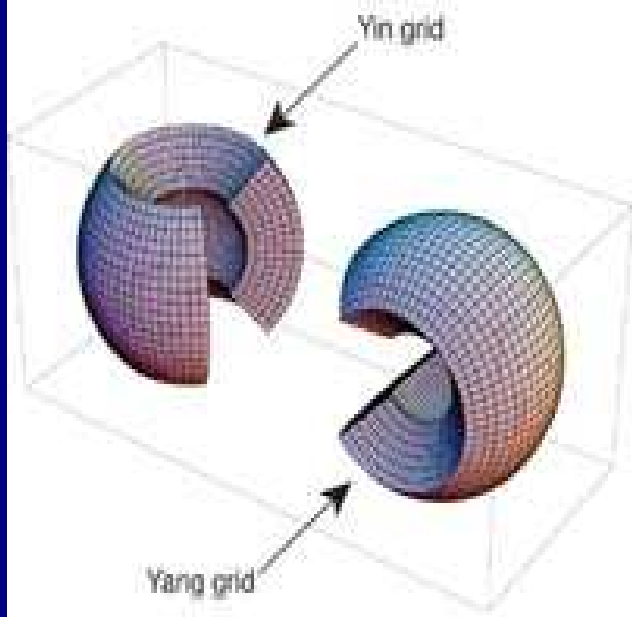
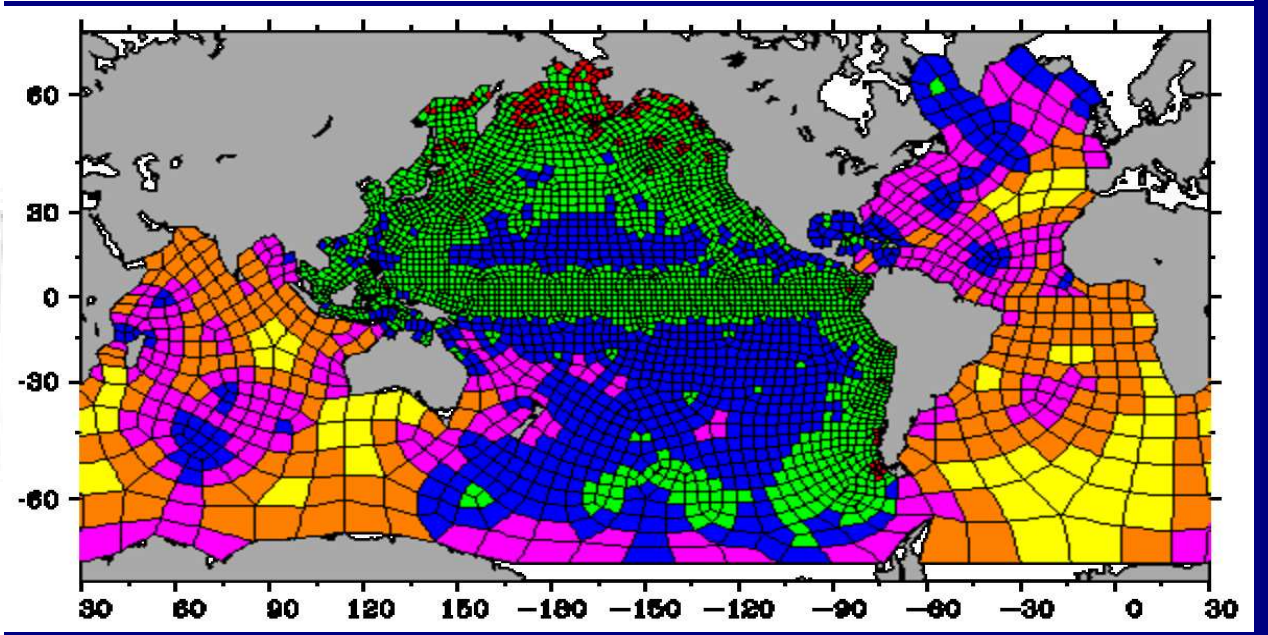
Horizontal grids in use in ESMs



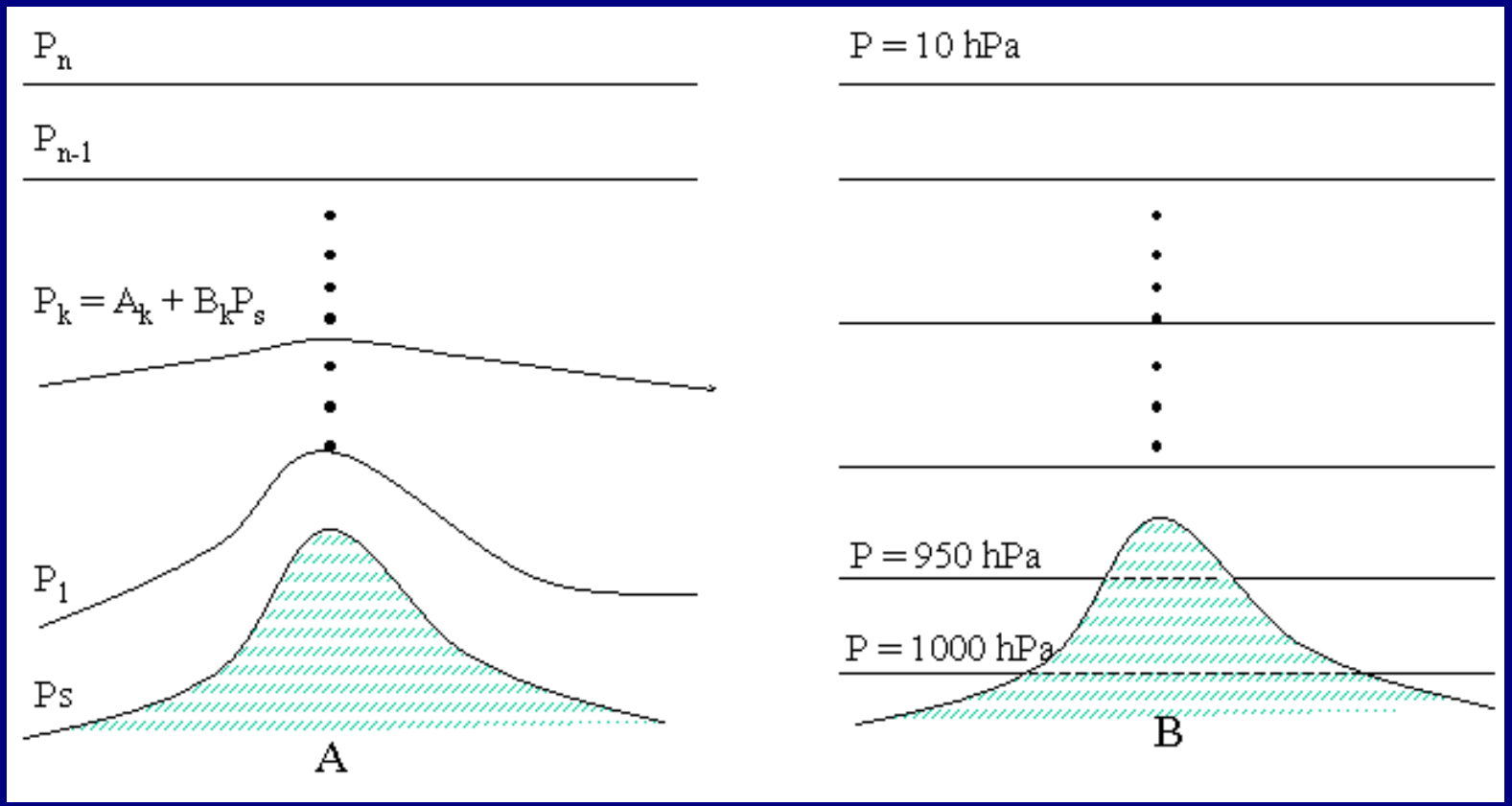








Vertical coordinates



The taxonomy of vertical coordinates distinguishes mass-based and space-based vertical coordinates. There is often an attempt to do something in the spirit of geo-referencing: invoking a “standard” reference grid: usually based on pressure levels in the atmosphere, and depth in the ocean.

Talk outline . . .

Concluding comments

- CF has undergone a two-year transition from informal maintenance by its authors to community governance.
- The CF Conventions transition seems moderately successful so far, but needs more active engagement by community volunteers.
- The CF Standard Names transition is also successful, with over 50 contributors and 900 standard names.
- Wide usage and real-world experience suggests CF metadata conventions are highly suitable for a broad community of data providers and users.
- To guarantee maintenance and ensure persistence as an internet resource, CF will need either
  - a single recognized authoritative organization to provide stewardship, or
  - a continued supply of interested and knowledgeable volunteers