Digitally Categorizing Atmospheric Systems

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Abstract

A numerical method is developed to digitalize atmospheric systems into 6 kinds:

1. High pressure, with warm temperature, and high density;
2. Low pressure, with cold temperature, and low density;
3. High pressure, with warm temperature, but low density;
4. Low pressure, with cold temperature, but high density;
5. Low pressure, with warm temperature, but low density;
6. High pressure, with cold temperature, but high density.

GFS model analysis data are used to calculate the above indices, and its plots show the patterns corresponding to what we know of subtropical high region, tropical low region, and others. Such index did not change with altitude, therefor give clearer picture of atmospheric systems.

IFS model analysis data are also used for analysis. Surprisingly, GFS and IFS have very different indices, especially in the upper troposphere.

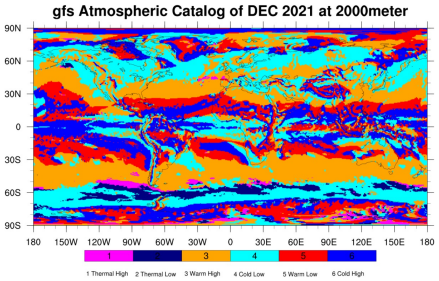
Introducing a method to digitally categorizing atmospheric Systems

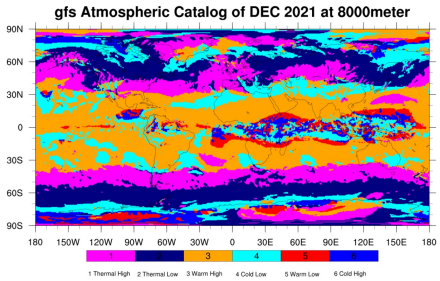
Based on atmospheric state equation and dynamic equation, one categorizing atmospheric systems as:

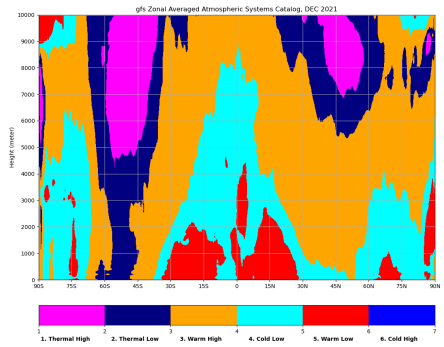
- Thermal-dynamic systems: $\nabla T \cdot \nabla \ln \rho \geq 0$
  1. $\nabla^2 P \leq 0$ Warm High Dense
  2. $\nabla^2 P > 0$ Cold Low Thin
- Non-Thermal-dynamic systems: $\nabla T \cdot \nabla \ln \rho < 0$
  - Thermal systems: $|R\nabla T| \geq |RT\nabla \ln \rho|$
    3. $\nabla^2 P \leq 0$ Warm High Thin
    4. $\nabla^2 P > 0$ Cold Low Dense
  - Dynamic systems: $|R\nabla T| < |RT\nabla \ln \rho|$
    5. $\nabla^2 P \leq 0$ Warm Low Thin
    6. $\nabla^2 P > 0$ Cold High Dense

Using GFS model analysis data

Monthly Mean of GFS model analysis of December, 2021 were used to calculate the atmospheric systems catalog as below, where top is at 2000 meter, middle at 8000 meter, and bottom is the zonal average.

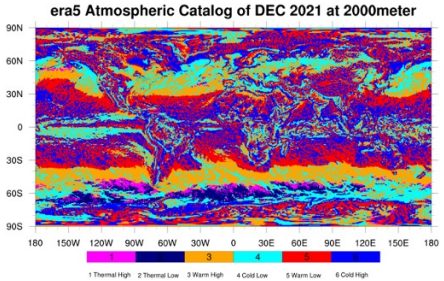


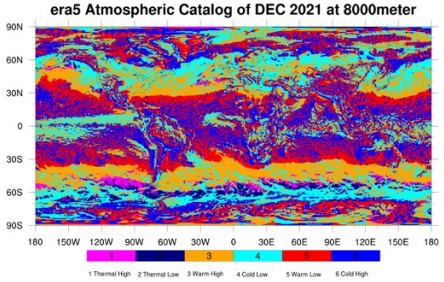


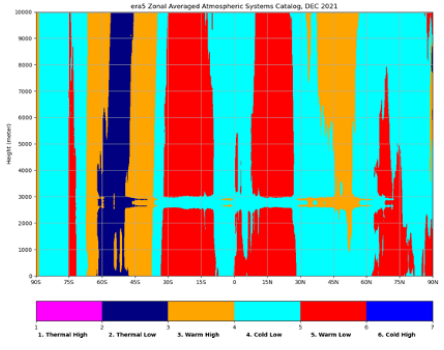


Using IFS model analysis data

Monthly Mean of IFS model analysis of December, 2021 were used to calculate the atmospheric systems catalog as below, where top is at 2000 meter, middle at 8000 meter, and bottom is the zonal average.







Conclusion

- Atmospheric systems can be divided into two modes: Thermal-Dynamic and Non-Thermal-Dynamic systems. Where Thermal-Dynamic systems have two kinds: Thermal-Dynamic High, and Thermal-Dynamic Low; Non-Thermal-Dynamic systems have two types: Thermal systems, and Dynamic systems. Thermal systems have two kinds: Warm High and Cold Low; Dynamic systems have two kinds as well: Warm Low and Cold High.
- GFS model data shows larger vertical variation of atmospheric systems catalog.
- IFS mode data shows very small vertical variation of atmospheric systems catalog.

Further Work

- Figure out the root cause of the zonal average difference, as we believe both model lack something in dynamic core to produce the correct convection/precipitation in tropical region.
- Prove the IFS model's lack of vertical variation is due to its design flaw.
- Find solution to generate the right convection and precipitation.
- Hope can put those solutions into GFS model.

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