TITLE: SEVERE STORM INITIATION AND DEVELOPMENT FROM SATELLITE INFRARED IMAGERY AND RAWINSONDE DATA

RESEARCH INVESTIGATORS:

R. J. Hung — The University of Alabama in Huntsville
Huntsville, Alabama 35899
Telephone: (205) 895-6077

R. E. Smith — Atmospheric Science Division
NASA/Marshall Space Flight Center, Alabama 35812
Telephone: (205) 453-3101

G. S. West — Atmospheric Science Division
NASA/Marshall Space Flight Center, Alabama 35812
Telephone: (205) 453-5218

SIGNIFICANT ACCOMPLISHMENTS TO DATE IN FY-84:

Available temperature, moisture and wind profiles from rawinsonde observations all over the United States were fed into the McIDAS system at the NASA/MSFC. Barnes (1964) scheme was used to maximize detail in numerical map analysis. The geographical distribution of potential temperatures, mixing ratio, and streamlines of flow patterns at 850, 700, and 500 mb heights was used to understand the prestorm convection and the horizontal convergence of moisture. From the analysis of 21 tornadoes that occurred in May, June, and August 1982, the following conclusions were reached: (1) Strong horizontal convergence of moisture appeared at the 850, 700, and 500 mb levels in the area 12 hours before the storm formation. (2) An abundantly moist atmosphere below 3 km (700 mb) became convectively unstable during the time period between 12 and 24 hours before the initiation of the severe storms. (3) Strong winds veering with height with direction parallel to the movement of a dryline, surface fronts, etc. (4) During a 36-hour period, a tropopause height in the areas of interest was lowest at the time of tornadic cloud formation. (5) A train of gravity waves was detected before and during the cloud formation period.

Rapid-scan infrared imagery provided near real-time information on the life cycle of the storm which can be summarized as follows: (1) Enhanced convection produced an overshooting cloud top penetrating above the tropopause, with cloud top temperatures 4 to 9°C below the temperature of the tropopause, making the mass density of the overshooting cloud much greater than the mass density of the surrounding air. (2) The overshooting cloud top collapsed at the end of the mature stage of the cloud development. (3) The tornado touchdown followed the collapse of the overshooting cloud top.

FOCUS OF CURRENT RESEARCH ACTIVITIES:

Study of the prestorm environment is the major focus of our current research activities. Available rawinsonde data are analyzed to determine the geographical distribution of potential temperatures, mixing ratio, and winds at heights from the ground to the upper troposphere. The purpose of study is to investigate the mechanisms responsible for the initiation of convection and the horizontal convergence of moisture.

The difference between the overshooting cloud-top height and the tropopause height is important in the development of severe storms. The collapsing rate of the overshooting turret is proportional to the volume of the cloud top above the tropopause and the temperature differential. The difference between the overshooting cloud-top height and the tropopause height may increase if the tropopause height decreases during the time period of the storm formation. The local tropopause height can possibly be modified by heating from sources in the stratosphere and/or the troposphere. There is a mutual interaction between the variation of the tropopause height and the latent heat released from the condensation of moisture and cloud formation, and also the interaction of pronounced fronts. Our current focus of research is to investigate these mutual interactions and their affect on the storm formation.

PLANS FOR FY-85:

In addition to the mutual interaction between the variation of the tropopause height and the heating from the troposphere due to the latent heat released from the moisture condensation and cloud formation, heating also can occur from the stratosphere due to the absorption of ultraviolet radiation and the releasing of infrared radiation during the conversion of oxygen to ozone. In the plans for the FY-85, the vertical profiles of ozone and the total ozone data will be investigated and compared with tropopause variations.

Not only is lightning linked to storm dynamics in the highly convective spring and summer thunderstorms, but it is also related to the dynamics in weaker winter storms. We will study the relationship between the lightning activity and the storm characteristics, such as cloud heights, growth/collapse rates of cloud tops, cloud top temperatures, etc., observed on rapid-scan imagery obtained from satellites.

RECOMMENDATIONS FOR NEW RESEARCH:

It is recommended that ozone and VAS data be added to the combination of weather maps, radar summaries, rawinsonde data, lightning observations, and rapid-scan satellite imagery used in studying the environment favorable for severe storm formation and development.

LIST OF PUBLICATIONS PREPARED SINCE JUNE 1983:

1. Hung, R. J., Dodge, J. C., and Smith, R. E., The life cycle of a tornadic cloud as seen from a geosynchronous satellite, AIAA J., 21, 1217-1224, 1983.

2. Hung, R. J., and Smith, R. E., Remote sensing of Arkansas tornadoes on April 11, 1976 from a satellite, a balloon, and an ionospheric sounder array, Int. J. Remote Sensing, 4, 617-630, 1983.

3. Hung, R. J., and Smith, R. E., Case study of the March 24, 1976 Elton, Louisiana tornado using a satellite infrared imagery,Doppler sounder, rawinsonde and radar observations, Int. J. Infrared and Millimeter Waves, 4, 375-400, 1983.

4. Hung, R. J., and Smith, R. E., Computer image processing of up-draft flow motion and severe storm formation from satellite, Flow Visualization, 3, 173-180, 1983.

5. Hung, R. J., and Smith, R. E., Overshooting cloud-top penetrated above the tropopause and the severe storm formation, Trans. Am. Geophys. Union, 64, 201, 1983.

6. Hung, R. J., and Smith, R. E., Remote sensing of severe storms over the Tibet-Tsinghai Plateau, Int. Sympo. on Remote Sensing of Environt., pp. 104, ERIM, Ann Arbor, Mich., 1983.

7. Hung, R. J., Liu, J. M., Tsao, D. Y., and Smith, R. E., Satellite remote sensing of convective clouds and precipitation over the Xizang Plateau of China, Univ. of Alabama in Huntsville Res. Rept. No. 390, pp. 50, 1984.

8. Hung, R. J., and Smith, R. E., Overshooting cloud tops, variation of tropopause and severe storm formation, Conf. on Satellite Meteorol./ Remote Sensing and Appl., ed., by J. Theon, AMS, Boston, Mass., 1984

9. Hung, R. J., and Smith, R. E., Visualization of convective flow patterns from infrared imagery analysis, Southeastern Conf. on Theoret. and Appl. Mech., 12, in press, 1984.

10. Hung, R. J., Liu, J. M., Tsao, D. Y., and Smith, R. E., Relationship between convective clouds and precipitation over Qinghai-Xizang Plateau area from satellite remote sensing and groundbased observations, Int. J. Remote Sensing, 5, in press, 1984.