Satellite IR Imagery



 $\begin{array}{ccc} 002 & 092 & 182 \\ \hline \end{array}$ Infrared satellite imagery for Nov. 10, 1998, based on radiation in the $10.7\mu \mathrm{m}\ window\ channel. \end{array}$

Radiances are indicative of equivalent blackbody temperatures T_E . Colour is used to enhance the prominence of the coldest (highest) cloud tops in the image.



Satellite IR image and weather reports, 00 UCT, 10 November, 1998.



Satellite IR image and weather reports, 09 UCT, 10 November, 1998.



Satellite IR image and weather reports, 18 UCT, 10 November, 1998.

This is indicative of the deepening of the convection.

This is indicative of the deepening of the convection.

The remnants of the cloud band that was over the Texas Panhandle at 00 UTC have become aligned with the secondary cold front.

This is indicative of the deepening of the convection.

The remnants of the cloud band that was over the Texas Panhandle at 00 UTC have become aligned with the secondary cold front.

In the final image, taken at 18 UT, the "yin-yang pattern" in the vertical velocity field is clearly evident.

This is indicative of the deepening of the convection.

The remnants of the cloud band that was over the Texas Panhandle at 00 UTC have become aligned with the secondary cold front.

In the final image, taken at 18 UT, the "yin-yang pattern" in the vertical velocity field is clearly evident.

The "chimney" of clouds emanating from the band of convection along the cold front curves cyclonically around the north side of the cyclone and spirals inward around its western flank, where heavy snow is falling at this time.





Shapiro and Keyser (1990) have described bent-back occlusions in terms of their "T-Bone structure". The pronounced current of subsiding air, called the dry slot, is wrapping around the southern flank of the cyclone, bringing an end to the precipitation in the areas immediately to the south and east of it. The pronounced current of subsiding air, called the dry slot, is wrapping around the southern flank of the cyclone, bringing an end to the precipitation in the areas immediately to the south and east of it.

Remnants of the warm frontal cloud band can still be seen advancing northeastward ahead of the system, but they are becoming increasingly detached from the circulation around the cyclone. The pronounced current of subsiding air, called the dry slot, is wrapping around the southern flank of the cyclone, bringing an end to the precipitation in the areas immediately to the south and east of it.

Remnants of the warm frontal cloud band can still be seen advancing northeastward ahead of the system, but they are becoming increasingly detached from the circulation around the cyclone.

This sequence of development is very much in accord with the typical cloud pattern observed in association with deep extratropical cyclones.

Water Vapour Imagery



 $\begin{array}{ccc} 00Z & 09Z & 18Z \\ \text{Satellite imagery for Nov. 10, 1998, based on radiation in} \\ & \text{the 6.7}\mu\text{m water-vapour channel.} \end{array}$

Satellite imagery for the water vapour channel yields additional insights into the structure and evolution of the storm.

Radiances in this band are indicative of the mid-tropospheric humidity.

Satellite imagery for the water vapour channel yields additional insights into the structure and evolution of the storm.

Radiances in this band are indicative of the mid-tropospheric humidity.

Air that has been rising tends to be moist, resulting in a high optical depth, a low equivalent blackbody temperature and a low radiance, and vice versa. Satellite imagery for the water vapour channel yields additional insights into the structure and evolution of the storm.

Radiances in this band are indicative of the mid-tropospheric humidity.

Air that has been rising tends to be moist, resulting in a high optical depth, a low equivalent blackbody temperature and a low radiance, and vice versa.

Low radiances, indicative of ascent are rendered by the ligher grey shades and high radiances, indicative of subsidence, by the darker shades.

Clouds with high tops are also visible.



Satellite IR and WV images for 00 UCT, 10 November, 1998.



Satellite IR and WV images for 09 UCT, 10 November, 1998.



Satellite IR and WV images for 18 UCT, 10 November, 1998.

IR Satellite Sequence 0915Z – 1815Z (hourly)

We now look at a sequence of infra-red satellite images made on 10th November, 1998.

The images are from the GOES-8 geostationary satellite, at hourly intervals. They are in the $10.7\mu m$ band.

The higher (colder) clouds are colour-coded for emphasis.





















Radar Imagery



Radar image at 0620 UTC, Nov. 10, 1998.

Radar imagery confirms the existence of a narrow, persistent band of deep convection along the advancing cold front, a feature known as a squall line.

Estimated rainfall rates increase by about a factor of five from the faintest echoes, rendered in light blue, to the strongest echoes, rendered in red.

Rainfall rates are heaviest along the leading edge of the band and trail off gradually behind it.

* * *

Radar imagery confirms the existence of a narrow, persistent band of deep convection along the advancing cold front, a feature known as a squall line.

Estimated rainfall rates increase by about a factor of five from the faintest echoes, rendered in light blue, to the strongest echoes, rendered in red.

Rainfall rates are heaviest along the leading edge of the band and trail off gradually behind it.

* * *

The hourly surface reports for Springfield, Missouri, located just to the east of the position of the squall line at 0620 UTC, are shown next.



Hourly surface reports for Springfield Missouri (KSGF). Springfield reported thunder at 04 and 05 UTC and then again at 07 and 08 UTC.

Some time between the 07 and 08 observations the temperature dropped by 7°C and the pressure rose by nearly 4 hPa, signaling a strong cold frontal passage.

The most pronounced shift in the wind (from SSW to WSW) did not occur at Springfield until the passage of the secondary cold front around two hours later.

Radar Sequence

0620Z - 0705Z







Radar Image, 1535 UTC

The radar image shown next, based on data taken at 15.35 Z, still exhibits a well defined squall line virtually coincident with the position of the primary cold front.

The major features in the distribution of radar echoes mirror the patterns in the satellite imagery.

The comma-shaped cloud band stretching from the southern tip of the squall line and wrapping around the poleward flank of the cyclone is evident on both images.

Radar Image, 1535 UTC

The radar image shown next, based on data taken at 15.35 Z, still exhibits a well defined squall line virtually coincident with the position of the primary cold front.

The major features in the distribution of radar echoes mirror the patterns in the satellite imagery.

The comma-shaped cloud band stretching from the southern tip of the squall line and wrapping around the poleward flank of the cyclone is evident on both images.

The slot of dry, relatively cloud free air intruding from the west and wrapping around the equatorward and eastern flank of the cyclone is also evident on both images.

This "yin-yang"-like configuration is the signature of intertwined ascending and descending air currents in the vertical velocity field, as seen earlier.

Radar Image, 1535 UTC

Radar image at 1535 UTC, Nov. 10, 1998.

Satellite Image, 1615 UTC

Satellite IR image at 1615 UTC, Nov. 10, 1998.

Radar Sequence

1530Z - 1615Z

